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THE EXTINCTION OF ANIMALS.

By R. Lydekker, B.A. Cantab.

IF it be true that, as compared with the pre-glacial epoch, we are living in an impoverished world so far as the larger forms of animal life are concerned, it is even more certain that our immediate descendants will be the heirs of a still more depopulated globe. Already the bison has disappeared from the American prairies, while of the vast swarms of antelopes and other large mammals which half-a-century ago peopled the plains of Africa scarce a tithe remains, and a few are well nigh, or even totally, extinct. A few years ago, indeed, it appeared that we were likely ere long to witness the complete extermination of many species of the larger African mammals; but, although we can never expect to see them again in their original multitudes, several of the South and East African governments are now taking measures to ensure the preservation of a few of the various species, and there is accordingly some hope that although the nineteenth century will ever deserve the reproach of posterity, as having been the one during which the world was to a great extent depopulated of the larger forms of animal life, yet that it will escape the crowning shame of having actually exterminated a host of species. Still, however, the indictment against our generation is heavy enough in all conscience; and there is no reasonable doubt but that the destructiveness which is so characteristic of human nature—whether civilized or otherwise—has led to the total extinction of two species of large African mammals within the last thirty years, while a third is only too likely to share the same fate. On the other hand, it must not be assumed that all the animals known to have become extinct within the historic period have succumbed directly to this demon of destructiveness. In certain cases, as we shall see in the sequel, the introduction of other animals by human agency has been the involuntary means of leading to the final extinction; while occasionally, as in the case of the great auk, a catastrophe of Nature has accelerated the climax. In other instances, it would appear that a species has been gradually dying out from unknown natural causes, in the manner which appears to be natural to all forms of animal life, where species and genera, like individuals, have but a certain allotted span of existence.

In the present article we propose to notice the chief animals, exclusive of invertebrates, which are known to have been exterminated, or are just verging on extinction, within the historic period; but before doing so we may briefly allude to a few others which urgently require protection, unless they are to share the same fate. Foremost among these are the African elephant and the so-called white, or square-mouthed, rhinoceros of the same country. Till within the last few weeks there were, indeed, strong grounds for believing that the latter magnificent animal, which at present is represented only by a few skulls and horns in English collections, had already disappeared; but we are rejoiced to hear that a few individuals still linger on in a remote corner of Eastern Africa, where it is to be hoped they will receive immediate and adequate protection. The walrus of the polar regions is another animal whose numbers have been woefully diminished of late years, and which likewise stands in urgent need of protective legislation, while a similar remark will apply to several species, or local races, of seals. In countries like New Zealand, where there were originally no native carnivorous animals, many of the indigenous creatures now stand in great jeopardy by the introduction of the latter, and it is only too likely that the flightless kiwi of those islands, noticed in our article on "Giant Birds," will eventually be exterminated by half-wild cats and dogs. The curious tuatara lizard of the same country is also likely to be killed off by pigs. In the Samoan Islands a similar fate long threatened the tooth-billed pigeon (*Didunculus*)—the nearest living ally of the dodo—but the impending destruction was fortunately averted by the bird having forsaken its original habits and taken to perching on trees.

Strictly speaking, the moas of New Zealand come within the category of animals exterminated within the historic period, since they were almost certainly killed off by the Maories; but as we have no direct historic evidence of their existence, no further mention of them will here be made. We shall commence our survey with three species which were the first to succumb.

When the Dutch Admiral Van Neck visited Mauritius in the year 1598, he found that island inhabited by a number of ungainly, flightless birds, which he called walkvogel (disgusting fowl), but which were afterwards termed by the Portuguese dodo (from *doudo*, a simpleton). Subsequently, many living examples of this bird (the form of which is probably well known to our readers) were exhibited in Holland, and their portraits painted by the two artists Savary. The museum at Oxford also once possessed a stuffed specimen, which, with the exception of the head and a foot, were eventually destroyed, as being

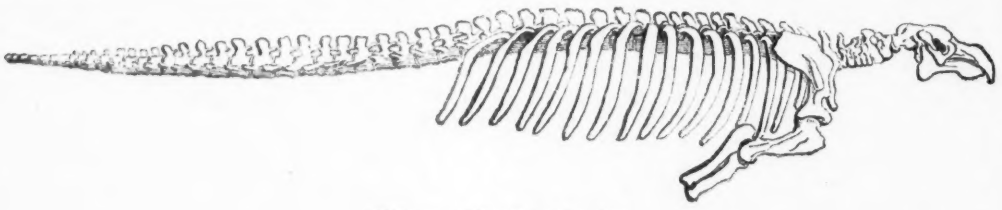
too much decayed to be worth preserving! In the year 1601 a Dutch ship captured twenty-four dodos for provisions, and others soon followed suit, so that at this time the bird was still common. It had, however, disappeared before the close of the century. The last notice of the living bird occurs in the journal of the mate of the *Berkley Castle* in 1681; and from the absence of any mention of it by Leguat, who visited the island in 1693, we may presume that it was already quite extinct. Although the numbers carried away by ships doubtless largely aided in its extermination, Prof. Newton, of Cambridge, is of opinion that the dodo was finally killed off by the pigs which had run loose over the island.

Near akin to the dodo was the taller and more lightly-built pigeon-like bird formerly inhabiting the island of Rodriguez, and known as the solitaire (*Pezophaps*). Our sole knowledge of this bird in a living state is derived from the accounts of Leguat, who founded a colony on the island in 1691, and who has left us not only a good account of its habits, but likewise an excellent portrait. When the solitaire became extinct is uncertain, but there is some evidence that it may have lingered on in the more remote parts of the island down to the year 1761. These birds were flightless, and the males much larger than the females, their rudimentary wing having a peculiar horny ball-like excrescence. Up to the year 1864 our museums possessed only a few bones of these strange birds, obtained from caverns in Rodriguez; but during the transit of Venus expedition a large number of remains were obtained, from which several more or less nearly perfect skeletons were set up.

Mauritius and Rodriguez also possessed another large flightless bird, known as the *Aphanapteryx*, and belonging to the rail family. By the fortunate discovery of an old painting, we learn that this bird had a long recurved bill and a brownish-red plumage. It was living in 1615, but seems to have disappeared by Leguat's time.

Another extinct Mauritian bird was the géant (*Leguatia*), which was a kind of coot, described by Leguat in 1695 as being equal in size to a goose. When it died out is unknown.

Our next instance of extermination relates to a very different kind of creature, viz., the great northern sea-cow (*Rhytina*), a near ally of the existing dugongs and manatis of the warmer seas. The rhytina, which was far larger than its living cousins, attaining a length of from twenty-four to thirty feet, was discovered by the ill-fated navigator Behring, on the island which bears his name, in the year 1741; and had it not been that he was accompanied by an excellent naturalist (Steller), it is quite probable that the creature might have perished without our ever having even heard of its existence. This sea-cow was confined to Behring and Copper Islands at the date of its discovery, where it existed in large numbers; but there is little doubt that it must formerly have had a much wider range, and that it was even then a waning race. Although Behring and his party were wrecked on Behring Island, where they remained for some ten months, it does not appear that they inflicted much damage on the sea-cows; but soon after, various fur-hunting expeditions were fitted out to Alaska, the members of which depended solely on these animals for food. So incessant, indeed, was the persecution of the unfortunate creatures, that by 1754 they had been exterminated on Copper Island, while by 1763 nearly all had been killed on their other haunt, and the last individual of their race is supposed to have perished either in 1767 or the following year. Up to 1883 three skeletons in foreign collections and a few ribs in the British Museum were all that remained of the rhytina; but since that date numerous remains have been obtained from the peat of Behring Island. Fortunately, the excellent description left by Steller, and some drawings which have come down to us from the navigator of Behring's party, give us a very good idea of the external form of the giant sea-cow.



Skeleton of Northern Sea-Cow.

Continuing our chronological survey, the next exterminated animals that claim our attention are the gigantic land tortoises of the Mascarene Islands, that is to say Mauritius, Rodriguez, and Réunion. In Mauritius these tortoises were first discovered by Van Neck, the discoverer of the dodo, in 1529, who relates that some of them were of such huge dimensions that six men could be seated on their shells. In Réunion, the voyager Boutehoc writes that he took twenty-four giant tortoises from beneath a single tree, in the year 1618; while Leguat, in 1691, states that in Rodriguez there "are such plenty of land-turtles in this isle that sometimes you see two or three thousand of them in a drove, so that you may go about a hundred paces on their backs." The Réunion tortoises, of which not a single specimen remains in our museums, seem to have been the first to disappear, although at what date is uncertain. Down to the year 1740 these reptiles were still abundant in Mauritius, but by 1761, when vessels were employed in transporting them to that island from Rodriguez as food, they had probably become scarce; while in both islands the whole race became extinct early in the present century, mainly owing to the ship-loads which were carried away for food; although pigs have largely aided in the work of destruction by devouring the eggs and young. It may be added that giant tortoises were formerly widely distributed over the world; but that within the historic period they have existed only in the Mascarenes, in Aldabra, to the north of Madagascar, and in the far distant Galapagos group. In Aldabra, whence they have been introduced into the Seychelles, they are now becoming very scarce, although we believe they receive some kind of protection. The Galapagos tortoises are, however, only too likely to share the fate of those of the Mascarenes, all the larger specimens having been already killed off. Indeed, it is highly probable that the Abingdon tortoise, remarkable for the extreme thinness of its shell, specimens of which were obtained in 1875 for our national collection, may already be numbered with the extinct.

With the pied starling (*Fregilopus varius*) of Réunion we return once more to birds. This beautiful species, the sole representative of its genus, and distinguished not

only by its pied plumage, but likewise by the presence of a coat of feathers on the head, is said to have been very bold and confiding in its disposition, and is believed to have been exterminated about fifty years ago.

Within the last few years a species of ke-ke parrot (*Nestor productus*), formerly inhabiting Phillip Island, near New Zealand, is likewise believed to have become extinct.

Our next species is one which may possibly be still existing, although, if so, it must be of extreme rarity. This is the gigantic blue coot (*Notornis Mantelli*) of New Zealand, which is almost the sole representative of its genus, although it has near allies in the purple water-hens (*Porphyrio*). This huge flightless bird was first made known to science on the evidence of some bones obtained from the volcanic sands of Waingongoro, in the North Island, and described by Sir R. Owen as belonging to an extinct form. Their discoverer, Mr. W. Mantell, succeeded, however, in obtaining the skin of an example which had been caught alive and eaten by some sealers in the South Island, some time in 1877; this skin, together with that of the second specimen, being now mounted in the British Museum. The second living specimen was taken in 1869, and a third in 1881, both in the South Island; but whether any others still survive is more than doubtful. As the fossilized remains of this species are not uncommon in the superficial deposits of both islands, we may probably refer its extinction in the North Island, and its extreme rarity in the South, to the Maories. If it still linger it is probable that wild pigs, dogs, or cats will ere long put a term to its existence. An allied species (*N. albus*), distinguished by its plumage, formerly inhabited Norfolk and Lord Howe Islands, but is now extinct.

With the great auk, or gare fowl, we come to a species completely exterminated in modern times, and of which the accounts are fairly complete. This bird, the largest member of its genus, and totally unable to fly, was restricted to the shores of the North Atlantic, ranging in Europe from Iceland in the north to the Bay of Biscay in the south, while in America it extended from Greenland to Virginia. These southern limits mark, however, only the winter range of the species, which was somewhat migratory in its habits. Its breeding-places were but few, the chief being the rock called Geirfuglasker off the coast of Iceland, and Funk Island on the Newfoundland coast; both these spots being bare, barren rocks very difficult of access. In spite of its slow increase (but a single egg being laid at a time), the great auk existed in countless numbers on Funk Island, where it was discovered by Cartier in 1534. Here for nearly two centuries it formed an unfailing food-supply for all vessels visiting the neighbouring seas; and it might have lived till now had not the custom arisen of men being landed on the island to spend the summer in slaying these birds for the sake of their feathers. It is said, indeed, that the auks were actually killed by millions, being first driven into stone enclosures, and then bludgeoned. When the bird disappeared from the American side is not quite clear, although it was probably somewhere about the year 1840. Four years later it had also ceased to exist on the opposite side of the Atlantic, the last European pair having been killed in the summer of 1844. What led to its rapid and final extermination in Europe was the sudden subsidence of the Geirfuglasker in 1830, which compelled the birds to seek other and more accessible breeding-places, where they were less protected from molestation. The last British example was killed in Waterford harbour in 1834. In addition to bones obtained from Funk Island, the great auk is now represented in collections only by some seventy-six skins, nine skeletons, and sixty-eight eggshells.

Before noticing the few remaining birds on our list, we may refer to two South African mammals which are now almost certainly extinct. The first of these is the fine antelope known as the blaubok (*Hippotragus leucophæus*), a near ally of the handsome sable antelope and roan antelope, characterized by their large scimitar-like and backwardly-sweeping horns. Indeed, the roan antelope is often confounded with the blaubok, although the latter was a considerably smaller and otherwise different species. When the blaubok was killed off cannot now be ascertained, but it was certainly abundant at the Cape in the first half of this century. Unfortunately, the British Museum has not a single specimen of this antelope, although a head is preserved in Paris.

The second African mammal is the quagga (*Equus quagga*), a near relative of the zebras, but distinguished by the hinder portion of the body being devoid of stripes. This animal was described by Sir Cornwallis Harris in 1839 as existing in immense herds, although its distribution was always very local; but of late years there is no definite record of a single specimen having been seen. If, as is probably the case, it is truly extinct, there is no record of the date of its disappearance. Of the almost total extermination of the square-mouthed rhinoceros, mention has been already made.

Curiously enough, the northern sea-cow was not the only animal discovered on Behring Island in 1741, during Behring's involuntary sojourn, which appears to have since become extinct. This second species was Pallas's cormorant (*Phalacrocorax perspicillatus*), the largest representative of its genus, and distinguished by its lustrous green and purple plumage, and the bare white spectacle-like rings round the eyes. This bird, which weighed from twelve to fourteen pounds, had small wings and was a poor flyer, with a stupid, sluggish disposition. Steller relates that it occurred in great numbers, and was extensively used as food by the members of Behring's party. About 1839, Captain Belcher, of the "Sulphur," received as a great rarity a present of one of these fine birds from the Governor of Sitka, by whom some other specimens were sent to St. Petersburg; but since that date nothing has been heard of the species, which probably became extinct within about a century of its discovery. Dr. Stejnegar, who visited Behring Island in 1882, instituted a careful search after this bird in vain, although he was rewarded by finding some of its bones buried in the soil. The species is now represented only by four mounted specimens, one of which is in our own national collection, and a few bones.

Another bird that appears to have become extinct within the last half-century is the beautiful black and golden sickle-bill, or mamo (*Drepanornis pacifica*), first brought to Europe by Captain Cook after his discovery of the Sandwich Islands, to which group it was restricted. This bird belonged to the family of honey-suckers, and was remarkable for the length of its curved bill. The brilliant yellow feathers from the back of the bird were used by the Hawaiian chieftains in the manufacture of their gorgeous feather-cloaks; and as one particular cloak, according to Mr. Scott Wilson, measures four feet in length and more than eleven feet round the base, it may be imagined what a number of birds of eight inches in length—and these only yielding the particular feathers on the back—would be required for its construction. Indeed, the manufacture of this particular cloak is stated to have lasted through the reigns of eight chieftains; and it is to the destruction thus caused that Mr. Wilson attributes the extinction of this beautiful bird, now represented in our museums only by some four stuffed examples.

XUM

In the Antilles a remarkable burrowing petrel, known as the diablotin, is also believed to be now extinct.

With the handsomely marked Labrador duck (*Camptolæmus labradorius*) we bring to a close our list of animals which can be pretty definitely affirmed to be extinct, although there are a few others over which the same fate is impending, even if it has not already befallen them. This duck was not unlike the common long-tailed duck (*Harelda glacialis*) in general coloration and size, although without the long tail of the latter. In the male, the body and primaries are black, and there is also a ring round the neck and a stripe down the head of the same hue; while all the remainder is white. During the breeding-season this species inhabited Labrador, but in winter its range extended as far south as New Jersey. According to Mr. F. A. Lucas, to whom we are indebted for much information concerning the extinction of several of the species noticed in this article, the Labrador duck was never common, and as no example has been seen since 1879 it may fairly be presumed to be extinct.

In conclusion, we may refer to a very remarkable mammal of which but a single example has hitherto come under civilized human ken. As most of our readers are probably acquainted, at least by name, with the large spotted South American rodent, known as the paca—a distant cousin of the familiar guinea pig—we shall assume that they know what we mean when we talk of a paca-like animal. Now, on a certain occasion somewhat more than twenty years ago, the inhabitants of Montana de Vitoc, in Peru, were surprised to find at daybreak a large rodent with the general appearance and coloration of a paca walking unconcernedly about the courtyard of a house. The creature differed, however, from a paca in having a tail of considerable length, as well as in its smaller ears and cleft upper lip; while dissection revealed other internal points of distinction. Now the curious part of the matter is that none of the natives of Peru had ever previously heard of or seen a similar animal (for which, by the way, the name of *Dinomys* was suggested), and from that day to this nothing more has been heard about the creature. Can it be that the specimen then seen and killed was the last survivor of its race, and that the *Dinomys*, whose existence was thus strangely revealed to us, must also be numbered with the extinct?

FLUORESCENCE AND PHOSPHORESCENCE.

By Vaughan Cornish, M.Sc., F.C.S.

When we view by reflected light the three following objects, a film or leaf of gold, a solution of sulphate of copper, and the leaf of a plant, we see that their colours are yellow or orange, blue, and green respectively. If, however, we view these bodies by transmitted light (*i.e.*, look through them at the light), we shall find that the thin gold film appears blue-green instead of yellow, whilst the solution of copper sulphate and the leaf of the plant appear of the same colours, viz., blue and green, as when seen by reflected light. It will be understood without explanation that the light transmitted by a body consists of all or part of the rays which have escaped reflection. In the case of a thin film of gold the rays of the orange end of the spectrum are reflected,* and other rays, the blue and green which have escaped reflection, are transmitted through the film. The colours of the object as seen by reflected and by transmitted light are, approximately, complementary colours.

How is it that in the case of a liquid, such as a solution of copper sulphate, and again in the case of the leaf of a plant, the colour as seen by reflected and by transmitted light is the same? The following experiment will serve to explain the action on light of the solution of copper sulphate.

The clear solution is placed in a vessel the sides and bottom of which are carefully blackened, and the mouth of the vessel is illuminated by ordinary white light. On looking into the vessel the contents appear, not blue, but *black*. If a blue tinge be distinguished, it is owing to the sides of the vessel not being perfectly protected with the required coating of dull black. In this case the copper sulphate, though illuminated by white light, does not give its well-known bright blue reflection, but reflects practically no light at all. If, however, a little finely-powdered chalk be introduced into the copper sulphate, the contents of the vessel immediately reflect the familiar bright blue colour.

What happens, obviously, is this: the light falling on the particles of white chalk is reflected back to the eye of the observer. In its passage into and out of the copper sulphate solution the light has been deprived by absorption of the orange part of the spectrum, and the blue rays alone emerge. Thus the colour of a solution of copper sulphate is the same whether light falls on it or comes through it, because there is, practically, no true reflection at all, but absorption only. When light falls on a vessel containing the liquid the blue colour is due to light from the background, or from solid particles in the liquid; the orange part of the reflected light being absorbed by the copper sulphate, and blue only passing. We see, therefore, that the colour of copper sulphate is always due to absorption and not to surface reflection.

In the case of a green leaf which shows the same colour by reflected and by transmitted light, the explanation of what goes on appears to be very similar to the last case. The light penetrates some little way below the surface of the leaf, and is there reflected back through the semi-transparent material. The chlorophyll absorbs the red rays and allows only the green to pass out again. With the leaf, as with the copper sulphate, there is no true surface reflection, such as is given by the gold film. The colours of most bodies, except the metals, are due to absorption, certain rays being absorbed and extinguished by the body.

A very interesting class of optical phenomena is presented by certain substances in which the absorbed rays, or some of them, are not extinguished, but are modified so as to emerge with a colour different from that which they originally possessed. The colour of a ray depends upon the period of vibration, the violet rays vibrating more rapidly than the blue, and the blue more rapidly than the red, which have the longest period of vibration. The rays of colour of shortest vibration period are termed the more refrangible rays from the fact that, in passing through a prism or lens, they are bent further out of their original path than the rays of longer period (the less refrangible), such as the red rays. Substances of the class to which we have referred (which are termed *fluorescent* substances) change rays of higher to rays of lower refrangibility, *e.g.*, violet to blue. A good example of the action of such sub-

* The action at the surface of a film of gold is evidently somewhat complicated. Thus polarized light falling obliquely on a gold-surface varies in colour after reflection with the inclination of the plane of polarization and the plane of incidence. The experiment is easily tried. If a sovereign be examined with a Nicol's prism, turned so as to cut out the light polarized in the plane of incidence, it appears whitish, like a bad shilling made of lead or pewter; but if the Nicol's prism be turned at right angles to its first position, the sovereign resumes its golden yellow appearance.—A. C. Ranyard.

stances is furnished by a solution of sulphate of quinine. To a superficial observer the solution appears clear and practically colourless. If, however, the eye be placed nearly on a level with the surface of the liquid on which a ray of white light falls, and a black screen be placed behind the vessel which contains the liquid, a bright blue colour is seen on the surface, and for a short distance below the surface of the liquid. The singular thing about the phenomenon is that this blue colour is not due to the absorption and emission of blue rays, but of rays of another colour, viz., the more refrangible violet rays. This can be shown by examining with the spectroscope the light transmitted by the solution. It is found that it is not the blue but the violet rays which are wanting from the spectrum. If the white light of the sun be caused to pass through yellow glass the emergent light produces no fluorescence in a solution of sulphate of quinine, the active violet rays having been removed by the yellow glass. Sunlight may, however, be passed through a violet glass without diminishing its power of causing a fluorescence in the quinine. It is possible to quench entirely a beam of white light by interposing first a violet-tinted glass which absorbs all rays but the violet, and then a yellow glass which quenches these violet rays. Such a combination is impervious to white light, but if a vessel containing a solution of sulphate of quinine be introduced between the two glasses, light at once shines through. This is because the violet rays falling on the sulphate of quinine are changed to blue rays, which the yellow glass has no power to absorb.

The properties of fluorescent substances have been applied to the important problem of mapping the ultra-violet portion of the solar and other spectra. The radiation of hot bodies, as has long been known, is not confined to the visible rays of the ordinary spectrum as perceived by the eye when light is passed through a prism. A thermometer, or a thermopile, placed beyond the visible red is still affected by the radiation which is not visible to the eye. The heating effect of the "ultra-red" rays is, in fact, very great. In the same way it has been found that there is radiation beyond the limit of the deepest violet which is visible to the eye. The ultra-violet radiation has but little heating effect, but is potent in producing chemical change. This portion of the spectrum of the sun can be made visible and "mapped" by the use of a fluorescent substance. The fluorescent substance placed in the invisible ultra-violet shines with a blue light readily perceived by the eye. The band of blue light is crossed by dark lines corresponding to the dark lines of the ultra-violet part of the solar spectrum. The dark lines are due to absorption of particular rays in the solar atmosphere. Where these lines occur there is no radiation, no ultra-violet ray, and consequently nothing to cause fluorescence. The blue band is therefore crossed by dark lines, the position of which can be measured as in ordinary spectroscopic work.

In most cases fluorescence lasts only so long as the substance is exposed to the radiation, but in some substances the emission of light continues after the exciting radiation has ceased to act. This phenomenon of persistent fluorescence is termed phosphorescence. It is well seen in the behaviour of the sulphides of the alkaline earths, which, after having been exposed to light, continue to shine for a long time in a darkened room. Many substances, however, which shine in the dark are not truly phosphorescent in the sense defined above, their "glow" depending on some slow chemical action, as in the case of common yellow phosphorus (*vide* KNOWLEDGE for June, 1892, "*Phosphorus mirabilis*").

It remains to enquire into the mechanism of the phenomena of absorption, fluorescence and phosphorescence.

According to the undulatory theory, light is the effect of a wave motion in a fluid medium. The character of the wave motion is not greatly different from that of waves in water. According to the molecular theory of the constitution of matter, substances are made up of small particles, termed molecules, which are in a constant state of vibratory and other motion. The mass of the molecules and the period of vibration is different in the case of different substances. We have to explain what takes place when the wave motion which constitutes light falls on a body composed of such vibrating molecules. Sir G. Stokes has furnished the explanation in the form of a simple analogy. Suppose a fleet of ships of different sizes to be lying at rest on a calm sea. Suppose a series of waves to pass over the surface of the sea without wind. The waves may be supposed to be the effect of a distant storm. Each ship will begin to oscillate. The time of oscillation, swing, or vibration will depend upon the size and mass of each ship, and may, or may not, in any particular case be the same as the periodic time of the waves themselves. The duration of a single oscillation of a ship may be the same as that of the wave, or it may be greater. In no case can it be less. The oscillating ships become themselves centres of disturbance from which waves are propagated over the sea. The periods of these waves may be the same as or greater than those of the original waves, but cannot be less.

The waves from the distant storm correspond to the light waves from a luminous body. The ships of various tonnage correspond to the molecules of different substances. Those ships which vibrate in a slower period than that of the original waves, and themselves cause fresh waves of the slower period, correspond to the molecules of a fluorescent substance. They act like the molecules of sulphate of quinine, which, when agitated by the rapid wave of violet light, take up themselves a slower period of vibration, and set in motion the surrounding ether waves of this slower period, which affect the eye with the sensation of blue light.

Properly speaking, these ships correspond more closely to the molecules of a phosphorescent body, since they would continue to vibrate for some time after the subsidence of the disturbing waves.

If we suppose that there are ships in our imaginary fleet which take up the same period of vibration as that of the disturbing waves, and if we suppose that these ships come to rest directly the disturbing waves cease, then we have the analogues of the molecules in the film of gold of which we spoke at the commencement of this article, for the molecules at the surface of the film of gold reflect the waves of a particular period, being set in motion in that period themselves, as is indicated by the fact that the light which passes through the film is robbed of just those rays which are reflected at the surface.

THE TEL-EL-AMARNA TABLETS.

By J. H. MITCHINER, F.R.A.S.

TEL-EL-AMARNA is the Arabic name for a village in Egypt situated on the east bank of the Nile, halfway between Minieh and Assiout, and about 180 English miles south of the ancient city of Memphis. It comprises a number of straggling Arab dwellings erected in a wilderness of sand and ancient ruins. About five years ago, some peasant women, searching, it is said, for fire-wood, but more probably for inscribed

scarabei or other Egyptian antiquities, with which practice has made them familiar, came upon a number of inscribed clay tablets. In the aggregate, some 320 of these documents were unearthed, and forwarded to the dealers of Cairo for disposal. A cursory examination sufficed to determine the fact that, although discovered on Egyptian soil, the writing on the tablets was neither hieroglyphic nor hieratic, but in the old Babylonian cuneiform character. The dealers communicated with the Government of the Khedive, with the result that the whole of the find was secured. Of the 320 letters, 82 were forwarded to the British Museum, 160 (mostly fragments) to Berlin, 60 were retained in the museum of Gizeh, and the remainder found their way into private hands.

Much interest attaches to the discovery of these tablets. The ruins amid which they were found form the site of the city and temples erected by the heretic King Khu-en-aten, a Pharaoh who, under the title of Amenophis IV., reigned in Egypt B.C. 1500. Among the tablets are a number of letters received by Amenophis III. and Amenophis IV. from reigning kings of Babylon, and reports from governors of outlying Egyptian provinces, as also copies of letters sent in reply. The whole of the writing on the tablets is in the Babylonian cuneiform, or wedge writing, and many are docketed with the date and from whom received in the Egyptian hieroglyphic character. The peasants who found them may be said to have stumbled on the ruins of the Foreign Office of the Egyptian Government of 3400 years ago, and accidentally to have brought to light an interesting political, social, and dynastic correspondence, covering the years from 1500 B.C. to about 1450 B.C., carried on between the Pharaohs of the fifteenth dynasty and the rulers of Syria and Chaldea. Valuable information is also found in the tablets concerning the Hebrews and their semi-conquest of ancient Phœnicia (Canaan), recorded in the books of Joshua and Judges.

To understand the references in the letters, it is desirable to recall the leading circumstances of the period to which the tablets refer. Amenophis III., who reigned thirty-five years, had married an Asiatic wife, the Princess Thi, and it was probably owing to the influence of this lady that Amenophis IV. discarded the religion of his ancestors in favour of that of his mother. After the death of his father, Amenophis IV. openly avowed his attachment to sun worship, introduced the Aten (sun's disc) into the ritual, and built the city, palaces, and temples now in ruins at Tel-el-Amarna.

Among the tablets in the Berlin Museum are six from Babylonian kings to Egyptian Pharaohs; in the Gizeh collection, two; and in the British Museum are three. These letters supply considerable information concerning the political relations existing between the Pharaohs of Egypt and the kings of Western Asia, besides details of the commercial relations between the countries, and offensive and defensive alliances, marriage customs, religious ceremonies, and court intrigues.

Of great interest are seven letters from the King of Mitani, a country east of the Euphrates, and near the Hittite fortress of Carchemish. Most of the letters from this king are in the Assyrian dialect of the cuneiform, which differed from the Babylonian cuneiform as Cornish from Lancashire, or Irish from Scotch. Carchemish was a Hittite fortress. From this spot we have in the British Museum some half dozen monumental fragments inscribed in a hieroglyphic character that has never yet been deciphered, and suggesting that the Hittite branch of the Semitic race, like the ancient Egyptians, possessed a sacred hieroglyphical form of writing of which the key is yet to be discovered. One of the Tel-el-Amarna tablets, from the Hittite prince Arzapi, is written in the dialect of the ancient Akkadian, or Mongol tongue of Mesopotamia. This ancient language occupied, for the Babylonian student, the same position in education as the Latin tongue does at the present day with us. Among the tablets in the British Museum, from the great library at Nineveh, are school books of the time of Ashur-bar-ni-pal, B.C. 668, containing Akkadian words, with their Babylonian equivalents written in parallel columns. It may be mentioned, in passing, that it is a question if modern Chinese has not been developed from this old Akkadian.

The Tel-el-Amarna letters being all in the cuneiform character were considered as unlikely to be readily deciphered at the Egyptian court. Hence it was the custom of the Babylonian kings to send interpreters with them, and reference is made to such messengers in several of the letters. But a scribe able to read and write the Babylonian cuneiform was undoubtedly kept by the Pharaohs for purposes of translation and for inditing replies. Some of the tablets are copies of such replies, written in cuneiform, but retained for reference, just as we in the present day preserve copies of important correspondence.

One of the most suggestive of the series secured by the British Museum is a letter from Burraburiyash, a Babylonian king of Karaduniyash, addressed to Amenophis IV. It commences by stating that Burraburiyash is himself in good health, and he hopes that Amenophis and his wives and children are also in good health, and that his country and army and government are in a prosperous condition. He goes on to remind the King of Egypt that in days gone by their respective fathers were agreed in friendship, and periodically presented each other with substantial tokens of mutual regard, and proceeds to refer to a gift recently received from the King of Egypt of two manehs of gold. He bluntly complains of its insufficiency, as much beneath the quantity his father, Amenophis III., was wont to send. He entreats him to forward at least half the quantity his father usually sent, and enforces his request by reminding the King of Egypt of certain obligations both he and his father were under for past friendly actions. On the occasion of the Canaanites sending a messenger to Babylonia inviting him to join in an invasion of Egyptian territory, he not only declined to make any league with them or have anything to do with it, but told the ambassador that if they induced any other king to join them in an attack upon the possessions of "his brother," the King of Egypt, he himself would go forth against them in battle. Further, he tells the King of Egypt that if the Canaanites had actually invaded Egyptian territory it was no fault of his, as by the hand of a trusty Babylonian messenger he had sent the King of Egypt notice of recent suspicious proceedings on the part of the Canaanites. He reminds Amenophis that as long as there is an offensive and defensive alliance between them the Canaanites are powerless to do much harm, and may be easily driven off. As a present (evidently with a lively sense of favours to come), he sends the King of Egypt three manehs of lapis-lazuli and five pairs of horses.

A letter from Amenophis III. to Kallima Sin, King of Northern Babylonia, is earlier in point of time, and scarcely less interesting. It is the only known letter of Amenophis III. in the Babylonian language and writing. No such King of Babylon as Kallima Sin was known until the discovery of these tablets. The letter commences:—"To Kallima Sin, King of Karaduniyash, my brother, thus saith Amenophis, the Great King, the King of Egypt, thy brother; I am well, may it be well with thee, with thy government, with thy wives, with thy children, with thy

nobles, with thy horses, and with thy chariots, and may there be great peace in thy land; and with me may it be well, with my government, with my wives, with my children, with my nobles, with my horses, and with my chariots, and with my troops, and may there be great peace in my land." In a previous letter, it would seem Amenophis had requested of Kallima Sin the hand of his youngest daughter, Sukharti, in marriage. Kallima Sin had replied:—"Thou wishest for my daughter to wife; but from the time when my father gave thee my sister to wife no man hath seen her, and none knoweth whether she be alive or dead."

Kallima Sin, in his despatch, had stated that "it was his custom to give his daughters in marriage to the Kings of Assyria, and that the messengers who took them to their future homes were treated with generous hospitality, and handsome gifts were sent in return by the husband's relatives." A fairly broad hint, and apparently producing the desired result, as in this letter Amenophis III. replies "that whatever the great kings and nobles of Babylon may possess, and are willing to give to Kallima Sin as dowries for his daughters, he not only possesses, but is willing to give far more than they all." It further appears that during the reign of his father, Thothmes IV., a similar application for an Egyptian princess in marriage, from a potentate of Babylon, had been received at the Egyptian court most ungraciously. Thothmes had replied—"The daughter of the King of the land of Egypt hath never been given to a nobody." Kallima Sin, in his letter, had quoted this unfortunate remark. Amenophis III. "declines to discuss" the words spoken by his father, and asks that they may be forgotten, as he wishes for "brotherhood." "Now let us two be brethren," he says, and proceeds to sketch out the main features of a commercial treaty between the two countries, but concluding with the renewed request that Kallima Sin would send him his youngest daughter, Sukharti, to wife.

In the end, the correspondence between the two kings resolves itself mainly into a question of dowry. From one of the tablets at Gizeh we find Kallima Sin writing to Amenophis as follows:—"With reference to thy request that my daughter Sukharti be given to thee to wife, my daughter Sukharti hath now come to the age of puberty and may be married; if thou will write unto me she shall be brought unto thee." The letter of Amenophis III. is probably a copy of the original sent to the King of Babylon.

Those interested in seeing the tablets in question will find seven specimens in the fourth Egyptian Room at the British Museum, placed in a glass case, and with descriptive notes in English attached.

RIVAL ALKALI MANUFACTURES.

By C. F. TOWNSEND, F.C.S.

THE manufacture of alkali is the most extensive chemical industry we possess. Alkali, in one form or another, is used in the production of nearly every article of commerce, and, owing to its vast importance, competition amongst rival makers is unusually keen. The struggle for commercial supremacy between our own and Continental countries has raged very fiercely round this particular trade during the last few years, and the contest promises to become still more acute. The quantity of salt decomposed in the manufacture of hydrate, carbonate, and bicarbonate of sodium, which are all included under the term "alkali," amounted in 1891 to more than eight hundred and forty thousand tons. Anything that gave a preponderating advantage to our Continental rivals would be little short of a national disaster, and it may prove interesting to take a glance at the existing state of affairs.

At present, there are two processes chiefly employed for turning out the different soda compounds, and a third is just beginning to enter the field. The oldest, the Leblanc system, may be described as indigenous and peculiar to these islands. In this process salt is heated with sulphuric acid, and the sulphate thus produced, after admixture with chalk and coal dust, is carried to a high temperature in a revolving furnace. By the last operation, technically known as the "black-ash process," carbonate of soda is formed (Na_2CO_3), together with calcium sulphide (CaS). This last body, after all the soda has been dissolved out of the mass, constitutes "alkali waste." It contains all the sulphur originally present in the sulphuric acid, and, until recently, was deposited on the waste ground adjoining the works. Here it has gone on accumulating until hundreds of acres are covered to a depth of more than ten feet with evil-smelling sludge. In spite of all precautions, a disgusting yellow liquid oozes from the mass. Getting into the drains, it meets with acids and gives out sulphuretted hydrogen, the disgusting odour of rotten eggs. Great expense is incurred in keeping it out of the rivers, and it has even been known to percolate into quarries and coal workings.

Not only is the waste an intolerable nuisance, but it contains millions of tons of sulphur, which are now lost. After years of research and a large expenditure of capital, a means has been discovered for recovering the sulphur in the calcium sulphide, and removing the trouble completely. The invention, due to Messrs. Chance of Oldbury, who are justly rewarded for their skill in overcoming great mechanical difficulties, is so successful that the alkali inspectors have enforced its adoption in all Leblanc soda works. Carbonic acid, obtained from the lime-kilns, is the active agent in the process. The gas is driven through the finely-ground waste by powerful compressors, and replaces the sulphuretted hydrogen, which passes on to a kiln invented by Mr. C. F. Claus. Here it is mixed with just enough air to burn the hydrogen without oxidizing the sulphur. The heat given out is sufficient to keep the kiln red-hot, and the sulphur is deposited in either the liquid or the solid state, according to its distance from the kiln. The system is not an expensive one to work, and it is expected that in a short time 100,000 tons of sulphur, valued at about £400,000, will be added to our national wealth every year.

The Leblanc process has a hard fight to maintain its very existence in the face of competing methods. Every year witnesses fresh prophecies as to its speedy demise; but it dies very hard, and contests every inch of the way. Sulphur recovery will lend it a further prop, and may serve to avert for a considerable period the dislocation which would ensue if the large capital sunk in the old industry had to be abandoned.

The Solvay, or ammonia-soda process, works on entirely different lines to that just described. The whole reaction is carried out with materials in a state of solution, brine being used instead of crystallized salt. In this wet method, ammonia and carbonic acid gases are blown through hot brine together. Chemically, it is equivalent to using ammonium bicarbonate; sodium bicarbonate (NaHCO) being formed in the solution, together with ammonium chloride. The crystals of bicarbonate are converted into the ordinary carbonate (Na_2CO_3) by heating, and are much cleaner than Leblanc soda. As the market value of all

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chemicals depends entirely on their state of purity, this gives the ammonia-soda process a distinct advantage.

The history of the up-hill struggle made by the wet process before attaining to its present position would form an interesting narrative in itself. Engineering difficulties of every imaginable kind had to be overcome; in fact, the leakage of ammonia at one time was so unaccountable that the chemists in charge were almost reduced to despair, and began to formulate new theories of chemical action to account for the missing molecules. Technical skill of the highest order, applied to every detail, and dogged perseverance in the face of heart-breaking obstacles, at last succeeded, and, for the last ten years, the ammonia-soda process has been gaining ground rapidly.

In both cases, alkali has not been the only product of the chemical reactions involved in the manufacture. Salt consists of chlorine as well as sodium, and its profitable utilization is the key of the disputed position. The Leblanc soda makers can turn a large proportion of their chlorine into bleaching powder and similar compounds, but the ammonia-soda makers have found no satisfactory means at present of utilizing theirs. Comparatively recently, all the hydrochloric acid, formed by the action of sulphuric acid on salt in the first part of the operations, used to pass into the air unchecked, to the great injury of every form of life. Now, the gases from the decomposing pots are passed through coke towers, down which a stream of water trickles, and less than five per cent. is allowed to escape. Chlorine, indeed, has become very valuable. It is the active principle of nearly all bleaching compounds, and an important constituent of chlorate of potash, largely used in fireworks. All the different ways of converting hydrochloric acid into chlorine are the same in principle—the hydrogen is burnt and the chlorine set free. In the venerable Weldon process, the necessary oxygen is supplied by a high oxide of manganese; in Deacon and Hurter's method the acid is mixed with air and passed over clay impregnated with a copper salt which acts as a go-between; and in yet another, nitric acid is the carrier of oxygen. The chlorine of the salt used in the ammonia-soda process goes to form ammonium chloride, as previously mentioned. When this is heated with lime to get back the ammonia the chlorine is converted into calcium chloride, from which it does not pay to recover it at present, although attention has been concentrated on the subject for a long while. In 1888 Messrs. Weldon and Péchiney invented a system for recovering chlorine from chloride of magnesium. This caused the greatest alarm for a time amongst our home manufacturers, for at the salt mines of Stassfurt 200,000 tons of magnesium chloride, containing 50,000 tons of chlorine, are thrown away every year. They feared that, if this could be worked up by the new method, the whole chlorine industry would be diverted to Germany. The high temperature (1000° C.) required in the Weldon-Péchiney process, however, played havoc with the plant, and the anticipations of its promoters have not been realized. Similar methods are being tried for utilizing the chlorine of the ammonia-soda process, but so far unsuccessfully.

The third process for the production of alkali is by means of electricity. When a current of electricity is passed through a solution of salt, sodium hydrate (NaOH) and free chlorine are produced. Electricity is, therefore, the ideal weapon for breaking up the salt, in theory. In practice, unfortunately, many difficulties arise. If the current passes through the solution without a diaphragm between the poles, the separated atoms re-combine to a large extent. If, on the other hand, a wall is introduced to keep the products apart, the resistance is increased enormously. The possibility of making soda and chlorine by electricity turns on the invention of a diaphragm, which, whilst separating the newly formed atoms, will not add largely to the resistance of the circuit. Messrs. Cross and Bevan, in their recent paper at the Society of Chemical Industry, describe a very ingenious diaphragm, by the help of which they claim that the electrical method can be worked successfully. They state that in America it is already in operation on a large scale, the chlorine produced being used for bleaching paper.

The successful method must ultimately be the one requiring the smallest expenditure of chemical energy, and which can make use of the cheapest available form. In the electrical process, for instance, the loss in converting the energy of the coal first into heat, then into electricity, and finally into chemical energy, may prove greater than in the Leblanc process, where the energy is used directly in the form of heat. In addition, every constituent of the raw materials must be recovered, or in other words, there must be no waste products.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

HABITS OF THE PICHICIAGO.

To the Editor of KNOWLEDGE.

Sir,—I regret to find that in my article in the December number I was misled by the artist as to the habits of the Pichiciago. The creature does not, as depicted on page 222, creep under rocks, but always inhabits sandy districts; and it has been suggested that the use of the shield at the hinder extremity is to act as a rammer in securely closing the entrance to its burrow with sand. It should also have been stated that the tail protrudes through a notch in the lower border of this shield, and not through a hole in the centre.

R. LYDEKKER.

THEORY OF THE SUN.

To the Editor of KNOWLEDGE.

SIR,—As in the last number of your magazine you have kindly obliged me with the enumeration of some objections to my explanation of the prominences as merely *evanescent illuminations caused by the propagation of chemical action in comparatively tranquil matter*, I hope you will allow me to state briefly what are the most important facts seeming to me in contradiction with the hypothesis of actual motion in prominences, and fully agreeing with my quite different explanation.

1°. We have the *undisturbed stratification of the solar atmosphere*, which, though continually crossed by the prominences, retains its heavier gaseous components firmly at its bottom. Now, we know that movements a thousand times slower than those of the supposed solar storms are already quite sufficient to impede the least trace of stratification in our terrestrial atmosphere.

2°. We have the *stratification of the prominences themselves*, never carrying the heavier metallic vapours they often contain at their bases to those greater heights where they consist almost only of hydrogen, helium, and some lighter metals as Na, Mg, and Ca.

3°. We have the *dissolving-view-character of many prominences*, almost instantaneously arising, continually altering their forms and, though big as some dozens of earths, sometimes vanishing in the space of a few minutes.

4°. We have the capricious and frequently abrupted *forms of the prominences*, which, especially when showing often-changing entirely discordant directions, do not convey any idea of possible actual motion.

5°. We have the *velocities of the supposed movements*, which, though corresponding sometimes (as in the case you have discussed in the Monthly Notices of December, 1880) with the velocities of projectiles shot upward under the influence of solar gravity, are often so irregularly altering their rate and direction that it is impossible to make them agree with any law or any hypothesis, either of eruption or explosion. The velocities, far from diminishing always with the height, very often *rapidly increase* or show *very irregular alterations at different heights in the same prominence* (Fenyi, "Publ. d Haynald Obs.," vi., 1892, p. 19; Memoire degli Spettr. Italiani, xviii., Deux "Eruptions Solaires, 5 et 6 Sept."; xxi. "Rapport sur les mouvements, &c., de la protubérance du 17 Juin"; Compt. Rendus, cxi., p. 562). M. Fenyi has also recorded instances of *wonderful long-lasting local velocities in the line of sight*, which could not be explained by the running of matter flowing from elsewhere (Memoire xx., "Prot. sol. extr. obs. à l'obs. Haynald"; xxi. *loc. cit.*). We know, moreover, that velocities of 1019 kilom. a second have been observed, velocities which, if really possessed by ejected matter, would cause it to leave the sun for ever. But such velocities being so stupendous that they are almost inconceivable, strengthen our doubts whether they may be really due to any actual motion of matter. I know very well that the movements of heavenly bodies show still greater velocities, but such movements cannot be compared with movements due to some local disturbance on the surface of such a body.

6°. We have the impossibility of imagining what a gaseous sun can be, and its photospheric clouds *the resisting walls and the eruptive forces* working together to produce such terrible explosions (Young: "The Sun," p. 210).

7°. We have the *perfect calmness* so often observed (*a*) in quiescent prominences and *in small flames* floating in the close neighbourhood of prominences in tremendous motion (Memoire xxi., "Sur une protub. d'une hauteur énorme obs. le 5 Mai, 1892"); (*b*) *in the solar atmosphere* at the very place where a few minutes before the terrible perturbation should have occurred (Mem. xviii., *loc. cit.*); (*c*) *in the (sometimes even spotless) photosphere* at the very places where above enormous prominences are showing their most extravagant velocities (Mem. xviii., *loc. cit.*: xxi., *loc. cit.*).

8° (last, not least). We have the certainty that a great many prominences form and grow larger *without any visible connection with the lower chromosphere*. And not only the quiescent cloud-like prominences do so, but also suddenly appearing short-lived prominences with enormous velocities—as, for instance, 485 kilom. a second upwards and 890 kilom. in our line of sight! Such a prominence I alluded to in my last letter as observed June 17th, 1891, in Kalocsa, the sun's limb having been continually watched before and having shown no alteration whatever and not the least connection with the stupendous prominence above. Such local outbreaks of luminosity suddenly appearing in the higher layers of the solar atmosphere, and running in different directions with fabulous and nevertheless *speedily increasing velocities*, cannot be caused by eruptions or explosions.

Whilst the numerous facts here enumerated are either in perfect contradiction with the hypothesis of actual motion or can only be made to agree with it with great difficulty, they correspond, on the contrary, as fully as possible with my hypothesis. Their explanation affords no difficulty at all if we consider the prominences as merely evanescent illuminations caused by the propagation of chemical action in comparatively tranquil matter. This hypothesis has, moreover, above all, the great advantage of explaining the origin of the prominences. That origin is the "chemical luminescence" in those places of the solar atmosphere where the loss of heat by irradiation causes dissociated matter to combine. The extension and fortuitous forms of these luminous places will depend (1) on small inequalities in the chemical composition and heat-emitting power of neighbouring places in the solar atmosphere; and (2) on the state of the lower photosphere. Spots, for instance, and pores emit less heat than the surrounding clouds, and therefore the atmospheric layers in their vicinity will be less protected against loss of heat than the layers elsewhere. Now, as loss of heat induces chemical combination and luminescence, it is plain that spots must be attended by powerful prominences, crossing there the atmosphere from the bottom to the top, and thus having an eruptive appearance. The rate of the propagation of chemical action, being dependent on the different circumstances indicated above, can be very slow as well as immensely rapid. My theory, thus forecasting the most different velocities, is also in that respect perfectly concordant with the observed facts.

I shall not enter here upon further particulars, which are fully discussed in my book; but I cannot finish without a brief refutation of the ordinary interpretation of the displacement of the prominence-lines. That displacement (never thoroughly or mathematically explained, moreover) is commonly considered as a proof of actual motion. But that interpretation is not infallibly sure. It must be granted, of course, that actual motion causes line-displacement; but there is no reason why a similar displacement should not be caused by the displacement of the luminous condition in tranquil matter.

I finish with the expression of my most sincere gratitude for the welcome opportunity, so kindly given to me, to submit some points of my theory to the judgment of your numerous readers. Yours faithfully,

Dr. A. BREster Jz.

Delft (Holland), January 18th, 1893.

[Without entering upon a discussion of the many interesting topics suggested by Dr. Brester's letter, two apparently fatal objections to his "chemical luminescence theory" of prominences may be indicated. The first is, that while the prominence-spectrum is composed fundamentally of the entire series of hydrogen-lines, visible and invisible, without admixture of continuous light, the spectrum of hydrogen burning in oxygen, long and carefully observed by Professor Liveing, is purely continuous, and contains no bright rays (*Philosophical Magazine*, October, 1892, p. 371). The second objection is that the rate of propagation of chemical action is, so far as terrestrial experience goes, exceedingly slow as compared with the enormous velocities testified to by line displacements in prominences. Moreover, the rapid translation towards or from the eye of the luminous condition in gases should give rise to greatly widened lines, unless the kindling action was instantaneously followed by extinction. But this is almost inconceivable. It may be added that the tattered condition of many prominences, and the spiral forms of others, can scarcely be accounted for otherwise than by real physical movements.—A. M. CLERKE.]

[Dr. Brester would be a better and more interesting theorist if he were more critical in collecting his facts. I gather that he is not speaking from his own experience as a solar observer, and must warn readers of KNOWLEDGE that in printing Dr. Brester's letter I do not endorse all his statements of fact. But in watching solar pro-

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minences I have myself seen many changes take place which it was difficult to explain on the theory of the upward projection of matter, combined with the assumption that I was looking at the same mass of cooling matter throughout the whole of the observation. In looking at the sun's limb the line of sight passes through a very great thickness of chromospheric matter, and one, no doubt, sees several prominence regions superposed on one another, as well as cool masses of gas which absorb the light of hotter gas behind. The very rapid motions Dr. Brester speaks of, if they exist in the chromosphere, are very rare, though motions of over 200 miles a second are not infrequent. An upward velocity of about 383 miles a second at the level of the sun's photosphere would, if there were no resisting medium round the sun, carry matter projected upward from the level of the photosphere away from the sun never to return; but with a resisting medium like the corona surrounding the sun it is possible that masses of gas may be shot upward with a much greater velocity, and yet never get away from the sun. The forms of the prominences seem to my mind clearly to indicate motion of matter in a resisting medium; and if there were nothing else to go upon, I think that I should have adopted a theory involving motion and projection into a resisting medium to account for them.

The even spherical surface of the solar photosphere does not seem to me to point to an "undisturbed stratification of the solar atmosphere in which the heavier gaseous components sink to the bottom," but rather to a rapid fall in temperature as we proceed upward from the sun, causing the well-churned and evenly mixed matter around the sun to emit different spectra at different levels, the matter in the lower regions being more highly heated than matter above, which can radiate more freely into space.—A. C. RANYARD.]

A BRILLIANT METEOR.

To the Editor of KNOWLEDGE.

DEAR SIR,—You may like to know that I with two other members of my family observed a brilliant meteor here on the evening of the 4th of January, at about 6.30 P.M. It passed near the pole star and left a trail about 10° long. It appeared to be going south. I see by the papers that a bright meteor was observed at about the same time in many parts of England and Wales, and that a meteoric stone seems to have fallen the same evening close to the drill ground at Freiburg, in Baden. I should like to know whether you think it possible that the meteor we saw can have travelled so far, and over what area a meteor can be seen. . . . . Yours, &c.,

Folkestone. W. H. WATSON.

[Brilliant meteors are seldom, if ever, seen at a height much above 100 miles. A meteor at a height of 100 miles could be seen on the horizon, if its light were not lost by absorption, at a distance of a little more than 900 miles from the place over which it was vertically situated. But the meteor observed by Mr. Watson does not seem to have been moving in the direction of Freiburg. I notice that the account telegraphed from Berlin, and published in the *Standard* of the 12th January, does not say that the meteor was observed to fall at Freiburg; but that fragments of a meteor had been found near to the drill ground, which were blue-green in colour, and contained quartz crystals. If the stones found contain quartz crystals they are in all probability not meteoric, for no quartz has up to the present time been found in bodies known to have a meteoric origin.—A. C. RANYARD.]

Science Notes.

In our last issue we referred to the arrangements now being made for an ethnographical survey of the United Kingdom. It is gradually being recognized that so far from being Anglo-Saxons, with a mere infusion of other races, we are really a very mixed people of diverse origin, and it is expected that the survey in question will dissipate many popular errors. Readers interested in the subject will find a mine of wealth in Canon Isaac Taylor's valuable book, "Words and Places."

The project of establishing a meteorological and astronomical observatory on the summit of Mont Blanc made considerable progress during the summer months of last year. The building will rest on the snow, and this, it is said, can be done with security. An astronomical dome, which is to complete the observatory, will also be taken in hand this year.

Mr. E. T. Newton has communicated to the Royal Society an important paper on some New Reptiles from the Elgin Sandstone (of triassic age). During the last few years a number of reptilian remains have been obtained from the Elgin sandstone at Cuttie's Hillock, near Elgin, which are now in the possession of the Elgin Museum and of the Geological Survey. These specimens represent at least eight distinct skeletons, seven of which undoubtedly belong to the Dicynodontia, and one is a singular horned reptile new to science. All the remains yet found in this quarry are in the condition of hollow moulds, the bones themselves having entirely disappeared; but gutta-percha casts have been taken of them. The casts thus obtained indicate the former presence of several species of *Gordonia*—one of the Dicynodonts—and reveal the nature of the skull, and, to some slight extent, of other parts of the skeleton. *Elginia mirabilis* is the name proposed for the skull of a reptile which, on account of the extreme development of horns and spines, reminds one of the living lizards, Moloch and Phrynosoma. The skull of this ancient saurian seems to show affinities with both Labyrinthodonts and Lacertilians, and is unlike any living or fossil form. Prof. Seeley's strange *Pariasaurus*, from South Africa (Karoo beds), may be a distant ally.

We hear a great deal nowadays about bacteria, and the science of bacteriology is making great strides. Although some bacteria are so deadly, others are of the greatest possible service to mankind. It has recently been discovered that these minute organisms play an important part in determining the quality of tobacco! The leaves of the tobacco plant, before they are worked up into cigars and finally handed over to the public, undergo certain fermentative changes. It was formerly supposed that the alteration in their condition thus brought about was due to purely chemical changes, but some interesting experiments recently made go to show that these important results are brought about by special micro-organisms. In a paper read before the German Botanical Society, Suchland gives an account of his recent investigations on the bacteria found in different kinds of tobacco. He has examined fermented tobaccos from all parts of the world and found that they contain plenty of micro-organisms, although but few varieties, mostly only two or three different species in any particular brand, and but rarely micrococcus forms. He finds that pure cultures of bacteria obtained from one kind of tobacco and inoculated on to another kind generated in the latter a taste and aroma recalling the taste and aroma of the original tobacco from which the bacteria had been in the first instance obtained. This discovery suggests great possibilities. Thus, it is

hinted that in the future it may be possible to raise the quality of German tobacco, not so much by careful culture and judicious selection of varieties, which has so far proved unsuccessful, as by inoculating with pure cultures of bacteria found in some of the fine foreign tobaccos, whereby similar fermentative changes may be induced in the German raw material, and the quality correspondingly improved. It will be highly interesting to watch the future results of this transplanting of bacteria.

The following are the lecture arrangements at the Royal Institution before Easter :—Sir Robert S. Ball, six lectures (for young people) on Astronomy; Professor Victor Horsley, ten lectures on the Brain; the Rev. Canon Ainger, three lectures on Tennyson; Professor Patrick Geddes, four lectures on the Factors of Organic Evolution; the Rev. Augustus Jessopp, three lectures on The Great Revival—a study in Mediæval History; Professor C. Hubert H. Parry, four lectures on Expression and Design in Music (with musical illustrations); the Right Hon. Lord Rayleigh, six lectures on Sound and Vibrations. The Friday evening meetings began on January 20th, when a discourse was given by Professor Dewar on Liquid Atmospheric Air, followed on January 27th by Francis Galton, F.R.S., on The Just-Perceptible Difference. The other lectures will be as follows:—February 3rd, Alexander Siemens, Theory and Practice in Electrical Science (with experimental illustrations); February 10th, Professor Charles Stewart, Some Associated Organisms; February 17th, Professor A. H. Church, F.R.S., Turacin, a remarkable Animal Pigment containing Copper; February 24th, Edward Hopkinson, Electrical Railways; March 3rd, George Simonds, Sculpture considered apart from Archæology; March 10th, Sir Herbert Maxwell, Early Myth and Late Romance; March 17th, William James Russell, F.R.S., Ancient Egyptian Pigments; March 24th, Discourse by Lord Rayleigh.

Fifty years ago the introduction of iron as a building material created a revolution in the science and art of shipbuilding, and of late years steel has largely taken the place of iron. But it now seems highly probable that a still greater change is coming. In the near future we may expect to see aluminium replacing steel to some extent. There are at present in existence five small craft constructed of this metal. There are three petroleum yachts, which were built last year at Zurich. One is a Swedish lifeboat. The fifth is a yacht which is now completing for sea in Germany. Aluminium has lately become cheaper, and to the shipbuilder it offers so many striking advantages that, even at its present price, it is sure of more general adoption. In strength and toughness it rivals steel, in non-liability to corrosion it is almost as good as gold, and in lightness it stands altogether alone.

Sir John Lubbock, in a recent lecture on the Habits of Ants, suggested the question whether ants were moral and accountable beings. Their communities were no mere collection of independent individuals, but organized communities, labouring with the utmost harmony for the common good. Various observers had recorded instances of attachment and affection. He himself had never noticed a quarrel between two ants belonging to the same nest. All seemed to be in harmony within the limits of the community. But ants not belonging to the same nest were always enemies, even if they belonged to the same species.

A valuable forthcoming work is that of Mr. Flinders Petrie, on "Meidoun." The author has visited the temple of the pyramid of Senefra, still quite perfect. One of the incriptions he found must be quite 5000 years old.

The tunnel at Niagara Falls is finished, and the plant for obtaining power will be in operation by next March. It is expected that a current of 45,000 electric horse-power will be transmitted from there to Buffalo, and 30,000 to other points.

Geologists will be glad to hear that the plans of the long-promised Sedgwick Geological Museum were under discussion at Cambridge last month, and there now seems to be a prospect of the early realization of the scheme for a Memorial Museum. The staff of the geological department of the university is also to be increased by the addition of a demonstrator in palæontology.

Good illustrations of the geological features of the earth's surface are still much wanted. We therefore welcome the publication of the first part of a large illustrated work on "The Volcanoes of Japan," by Professors John Milne and W. K. Burton, with photographs by K. Ogawa. The present part contains ten plates, and is devoted to the illustration of the most famous and beautiful of all the Japanese volcanoes—Fujisan (or Fuji Yama, as we still find it in our atlas). The photographs are reproduced as permanent collotypes 11 by 8 inches, and are in every way admirable. Last year we called attention to a similarly illustrated work on "The Great Earthquake in Japan, 1891." We hope soon to see the second part. The book may be obtained of Messrs. Kelly and Walsh. Professor Milne gives in his text some interesting particulars about this great volcano.

Mr. Preece's wire to wire communication, mentioned in our January issue, is not a new idea. The late Mr. Willoughby Smith made similar tests some years ago. Before the Indian Mutiny in 1857, Sir Wm. O'Shaughnessy, Director-General of Electric Telegraphs in India, made fairly successful experiments in that direction, which, but for the mutiny, would, no doubt, have been continued and improved.

The great American pneumatic gun is described by a visitor to Shoeburyness as capable of throwing a shell having a charge of 600 lbs. of dynamite. It resembles a huge telescope, pointing upward at an angle of 30 degrees, and is 70 feet long. The missile is discharged by compressed air, and yet its discharge produces a report and a cloud of smoke, just as if gunpowder had been exploded. The shots were carried a mile and a half.

THE LUNAR APENNINES.

By A. C. RANYARD.

THE range of lunar mountains which runs diagonally across our plate is described by the Rev. T. W. Webb, in his *Celestial Objects for Common Telescopes*, as being "more like the mountains of the earth than is usually the case." This range of mountains is known as the lunar Apennines. It rises gradually on its south-west flank, but is comparatively precipitous on the other side, as though it was a mountain range composed of strata tilted or tipped up towards the north-east. But the greater steepness on one side of a mountain range must not, without further evidence, be taken as proving that the mountains are built up of stratified rocks which have been laid down beneath a lunar ocean; for there are many terrestrial volcanic ridges which are steep on one side and slope away gently on the other, ridges which exhibit a stratified structure being built up of beds of volcanic ash, sometimes alternated with

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lava. Thus the Monte Sumna, which partly surrounds Vesuvius, is steep on the inside towards the present cone, and it slopes away gently on the outside. On the moon we have many such volcanic rings. The lunar crater Archimedes (shown on the lower right hand side of our plate) is surrounded by an elliptical ring which is steeper on the inside than on the outside.

The question whether the lunar Apennines are similar in character to terrestrial mountain chains, or whether they form a part of a vast ring of volcanic origin which once surrounded the Mare Imbrium, is one which has very important bearings on the theory we are led to adopt with regard to the early history of the moon, and also with regard to the early history of the earth.

If the Mare Imbrium is not an ancient sea bed, but is the floor of an immense volcanic crater, the lunar Apennines must be very old, probably far older than any terrestrial landmarks, for they must have been raised at a time when the moon was hot enough to pour forth a sea of lava which covered a seventieth of the entire lunar surface—a sea which must have glowed with a red heat, when the lava was liquid enough to flow evenly over the entire area of this titanic crater, forming a spherical bed. For the floor of the Mare Imbrium, as well as the floors of the other great lunar planes, are all curved, and they appear to correspond with the spherical curvature of the lunar surface.

The even curvature of the floor of the Mare Imbrium will be recognized in our plate. The sun has risen high upon the western side of the Mare, but the eastern side of the floor is only just emerging gradually from darkness. Many of the large lunar craters have similar flat sea-like areas within them. Thus Archimedes, the crater referred to above, has a level floor some fifty miles in diameter, and some seven hundred feet above the level of the surrounding Mare Imbrium. Other lunar craters have a flat floor and a central peak or mountain, but the Mare Imbrium has no central elevation, nor have any other of the lunar maria, though they are all more or less circular or elliptical in outline. The circular walls of the lunar craters are very frequently terraced on their inner and steeper side as if there had been a tendency for the crater edge to slip down in parallel ridges, or as if there had been many ebbings and flowings of the lava sea within, leaving terraces at different levels. But the precipitous south-eastern declivity of the lunar Apennines does not exhibit such terraces, and it is much more irregular in outline than the rings which surround the majority of lunar craters. In order to realize the uneven character of the steep south-east front of the lunar Apennines the reader should compare the curving white projections shown in the plate published with this number with the beautiful pictures of the same region taken by the Brothers Henry, which were published in the December number of KNOWLEDGE for 1890, and with the lunar photographs taken at the Lick Observatory, published in KNOWLEDGE for October, 1889. It will be seen that the north-eastern side of this mountain range is much notched and broken into projecting promontories capped by peaks of very unequal altitude. The loftiest of these summits is known as *Huygens*. It rises, according to Neison, to a height of 18,000 feet, and according to Mädler to a height of 20,900 feet above the plain below. Its long straight edged shadow may be seen in our plate stretching to a distance of rather more than fifty miles across the Mare Imbrium. At the summit of this lofty peak is a minute crater, not discernible in the photograph, but easily seen under favourable circumstances with the telescope. To the north-west is another lofty peak known as Bradley, which reaches a height of 13,600 feet.

Along the south-eastern flank of the lunar Apennines is a somewhat broken range of lower hills such as would be called foot-hills in the Rocky Mountain region of North America. A little further to the south-east, and just catching the rays of the rising sun, is a narrow wall, parallel to the general backbone of the Apennine range. This is one of the narrow walls or ridges on the moon which has been referred to as being possibly an immense terminal moraine built up of rocks brought down during a glacial epoch. If such a theory could be supported, it would prove that the moon must have possessed, since the raising of the Apennine range, an extensive atmosphere as well as a considerable supply of water. But this ridge does not seem to me to have the characteristics of a glacial moraine which, in terrestrial mountain regions, generally stretch across a valley in a curve that is concave towards the hills from which the glacier that built the moraine descended. With a higher sun, this curious ridge takes the appearance of a very narrow bright line joining two small craters. Whether some of the smaller ridges across lunar valleys, which were pointed out by Prof. Frankland as due to glacial action, are terminal moraines, I am not prepared to say. The lunar Apennines appear so much more rugged than the formations which are apparently more recent, that one would be inclined to believe that time brings about a change in the form of lunar mountains. But the change need not necessarily have been brought about by the carving action of ice and water. The volcanic vents that one sees in various parts of the lunar Apennines, must have done something to increase the irregularities by the addition of matter ejected from below; and the earthquakes which accompany such eruptions would no doubt tend to shake down the softer and weaker portions of the range. As we learn more of the history of our own mountain ranges, we may learn how to interpret with greater certainty the forms of the valleys and the peaks into which this ancient range of lunar mountains is broken up.

It seems to me that we have some evidence of drainage action upon the moon, in the curious dark patches on the plains at the base of mountain slopes—see for example the delta-like patch in the bay within the foot hills between Archimedes and the lunar Apennines—a dark form which is visible when the sun is at all altitudes, showing that it cannot be due to shadows cast by irregularities in the surface. In order to make sure of what I refer to, I would ask the reader to compare our plate with the Henry photographs (KNOWLEDGE, December, 1890), and with the Lick photographs (KNOWLEDGE, October, 1889). There are also some dark spots, which I believe to have a similar origin, on the other side of the lunar Apennines, in a line between Archimedes and Manilius, a crater about 25 miles in diameter, to the south west of the Apennine range. These dark markings, as well as the similar dark patches to the south-west of the Palus Nebularum,* are seen as dark when the sun is at all altitudes; and they are generally found near to the base of mountain slopes in the equatorial regions of the moon. It is hardly conceivable that these darker patches can be due to a difference in the nature of the surface rocks—which crop out always towards the base of mountain slopes—and the form of the patches seem to indicate a flow of matter down a slope. They can hardly be lava streams, for they are not associated with adjacent craters, and the radiating narrower forms which have been usually assumed to be lava flows from craters are generally whiter than the surrounding surface.

* The Palus Nebularum is the smaller plain to the east of Manilius, and to the south-west of the lunar Apennines.

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SOUTH

WEST.

EAST.

Archimedes

THE LUNAR APENNINES AND SURROUNDING REGION.

From a photograph taken by Mr. H. C. Russell, Government Astronomer at the Observatory, Sydney, New South Wales.

Printed by Morgan & Kidd, Richmond.

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CATERPILLARS.—IV.

By E. A. BUTLER.

(*Continued from page* 7.)

THE frequent handling of a hairy caterpillar naturally causes some of the hairs to become detached, thereby often occasioning much annoyance to the operator, and the finer the hairs the more disagreeable the results. These slender little appendages, partly by reason of their barbed structure, and partly in consequence of the minuteness of their points, cling to or penetrate the skin, and are difficult to get rid of; rubbing generally makes matters worse, only causing the hairs to cling all the more tightly. They thus act as mechanical irritants, producing a tickling and worrying sensation, especially when they become attached to the skin between the fingers. The caterpillars of the drinker and oak egger moths (Fig. 11) are perhaps the greatest sinners in this respect. They are closely covered with a short thick pile, which not even the most careful and tender handling can keep from coming off; the little hairs enter the skin, sticking in it upright, but the fragments are so short that it is not easy to see them, and they are usually too fine to be seized between the finger nails or to be extracted by means of tweezers. But there are a few insects whose power of annoyance is far greater than this, so great indeed as to suggest the presence of some poisonous principle in the hairs. Amongst British insects there are two which have attained this undesirable notoriety, and which, when handled, produce exceedingly irritating and painful swellings. They are closely allied species called the gold tail and brown tail moths (*Porthesia auriflua* and *chrysorrhœa*). The moths may be very easily recognized, as they are like no other British insects; they are of a satiny or creamy white colour, the former having the hinder parts of its body clothed with bright golden silky hairs, and the latter having the same parts covered with soft down of a deep brown colour. They are often very abundant, and then the caterpillars do a great deal of damage to hawthorn hedges, sometimes absolutely stripping them of their bright spring foliage.

FIG. 11.—Hairs of larvæ of (A) Drinker Moth; (B) Oak Egger; very greatly magnified.

The caterpillar of the gold tail is the handsomer of the two, as well as the more virulent. Its black body is adorned with vermilion stripes and little warts, from which spring clusters of white (Fig. 12) and black hairs in pretty contrast. It has also on its back two orange, cup-shaped, wax-like bodies, which are glands for the secretion of an odoriferous and easily vaporizable liquid. These caterpillars are common in the early summer, and may easily be reared, but they should on no account be touched. If they are handled, and the hands are then brought into contact with the face or neck, large oval wales are produced on these parts in a few minutes, and these quickly become highly inflamed and itch intolerably; rubbing, of course, only aggravates the discomfort. After a while the swellings subside and the irritation is allayed, so that the inconvenience is merely temporary; still it is an extremely undesirable experience while it lasts. Sometimes merely holding the head over the cage while the food is being changed is sufficient to cause the symptoms to appear. No doubt small fragments of the hairs are wafted about in the air, and any little disturbance like that caused by putting fresh food in brings them into contact with the skin. The hairs retain their disagreeable power for a long time. Many of them are woven up with the silk of the slight cocoon the caterpillar makes when it becomes a chrysalis, and if such a cocoon be pulled to pieces even long afterwards, the operator not unfrequently suffers in consequence. This seems to throw doubt upon the suspicion that the hairs are poisonous, since it might be expected that a poisonous secretion would be operative only when freshly formed and still moist. The fluid above mentioned as secreted by the glands on the back does not appear to be used to supply the hairs, and indeed it is itself not of an acid character, and hence is less likely to be able to produce irritation. The brown tail caterpillar, which is rather like the gold tail, but not so brilliant, produces similar results, but not in so marked a degree, at least in the experience of some people; but it must be admitted that the testimony of entomologists varies on this point, and some denounce the brown tail as the greater delinquent of the two. Possibly the difference may be a matter of individual temperament. In any case, collectors of caterpillars should beware of these two species, and on no account handle them; indeed, it is safe to lay down the rule that, for their own sakes quite as much as for the collector's, caterpillars of whatever kind should be handled as little as possible.

FIG. 12.—Cluster of white hairs from larva of Gold Tail Moth.

Other species in tropical countries produce results which are even more disagreeable. Mr. Poulton once exhibited to the Entomological Society of London a large hairy caterpillar from the island of Celebes. It was described by the natives as causing a complaint something like erysipelas in those who touched it. The bristle-like hairs, which were hollow and barbed, easily penetrated the skin and then broke off. Of course, as the hairs were hollow, it is probable that they contained a poison during the lifetime of the insect, but as the specimen had been preserved in spirit, that point could not be determined. The caterpillars of the processionary moths of the Continent, so called from the wedge-shaped phalanx they form when they go out to feed, produce great irritation, accompanied by inflammation and eruptions of the skin, and their hairs are not only barbed, but have been found to contain formic acid, facts quite sufficient to account for the effects produced.

Glands for the secretion of protective liquids are frequently found on caterpillars, and are probably of much commoner occurrence than has hitherto been suspected. Almost all the members of the family *Liparidæ*, to which the gold tail and brown tail, as well as the "tussocks" and "vapourers" belong, have been found by Mr. Poulton to possess them. The caterpillar of the puss moth, again (Fig. 13), has a large gland just beneath its mouth, from which it can shoot forth strong formic acid with considerable force, the expulsion being caused in this case as in others by the partial eversion of the gland, which consists of a sort of pocket in the skin. The caterpillars of certain saw-flies, which are much like those of moths, also have the power of squirting fluids with

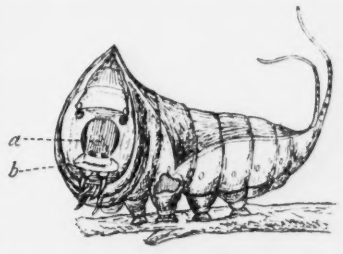


FIG. 13.—Caterpillar of Puss Moth, in terrifying attitude (after Poulton). *a*, head; *b*, position of formic acid gland.

great force from small glands distributed over the body. These liquids are very volatile, and therefore, though the jet itself may not reach the assailant, the atmosphere around becomes charged with the vapour and is thus rendered repulsive, warning off the enemy.

As caterpillars constitute the staple food of many vertebrate animals, especially certain species of birds and reptiles, it becomes an interesting enquiry whether, amongst the great multitude of species, all are equally palatable to each insectivorous vertebrate, and would therefore be taken indifferently; or whether, on the other hand, any choice is exercised, and there are any kinds of caterpillars for which a decided preference is manifested, or whether any are absolutely repugnant to the taste, and if so, how the distasteful ones are recognized so as to be avoided. Observations and experiments made in connection with various kinds of birds and reptiles in confinement have clearly demonstrated that all caterpillars are not regarded by them as alike suitable for food, and there are many indications that, when any are rejected or only reluctantly taken, it is because of something unpleasant in the taste that they are thus treated. The more refined taste of modern civilized society is prejudiced against the use of caterpillars as an article of diet; nevertheless, it is a well-known fact that some species are sufficiently palatable to have been used with relish as food by human beings; and though it would be unsafe to argue at once from human partialities to those of the lower animals, there is probably enough in common between the palate of man and that of bird or reptile to permit of our forming some notion as to what might be *un*palatable to these lower animals. For example, we know enough of the effects of acrid or fœtid liquids to render it a safe assumption that caterpillars which secrete such fluids will for that reason prove to be unpalatable to birds and reptiles; and the same might be expected to be the case with such as feed upon plants possessing strong and disagreeable tastes or poisonous properties. At the same time, just as to us a little acidity is by no means a drawback in an article of diet, but on the contrary imparts a stimulating and refreshing flavour, so caterpillars that secrete acid juices might be expected not to become thereby unpalatable unless the secretion were excessive. This supposition is borne out by the instance of the puss moth caterpillar above referred to. Notwithstanding its secretion of formic acid, it is eagerly devoured by lizards, and that too in defiance of its somewhat alarming aspect and the whisking movement of its whip-like tails, so that it must evidently be regarded in the reptilian world as a savoury morsel whose acquisition is worth some risk.

At a meeting of the Entomological Society of London in 1867, Mr. A. R. Wallace, the apostle of natural selection, ventured to predict that caterpillars which were very brightly coloured and conspicuous would be found to be distasteful to some at least of their bird enemies, the suggestion being that the caterpillars had acquired the intensity of their colour by a process of natural selection, their conspicuous appearance serving as a danger signal or warning to their vertebrate foes that they were inedible; thus the warning became the more perfect and the protection afforded therefore the more complete in proportion to the intensity of the coloration. Acting upon this hint, several competent observers made repeated trials of the behaviour of various birds and reptiles towards about a hundred species of caterpillars. Mr. J. Jenner Weir, experimenting with such birds as robins, yellow hammers, chaffinches, thrushes, &c., showed that green caterpillars were always eaten with relish, as were also those that were dull-coloured, with fleshy bodies and smooth skins; brown or green geometric larvæ also were invariably eaten. Very conspicuous larvæ, on the other hand, such as those of the magpie moth (*Abraxas grossulariata*) (Fig. 14), which is distinctly marked with black and orange on a cream-coloured ground, the figure-of-eight moth (*Diloba cæruleocephala*), which is greenish or bluish white, with distinct black and yellow spots and stripes, and the mullein moth (*Cucullia verbasci*), which is also greenish white with black and yellow markings, were not molested by the birds.

Fig. 14.—Caterpillar of Magpie Moth.

Miss Lilian Gould has recently made further experiments with the two last-named insects, which seem to indicate that these caterpillars are really disagreeable to the avian taste. The bird employed as judge was a tame jackdaw of about a twelvemonth old. As it had been captured while still unfledged, it certainly could have had no personal experience of caterpillars in a state of nature; and during the twelvemonth of its captivity, its only chance of gaining any knowledge of them and their edibility would be the possible fall into its cage of casual specimens dropping from the beech tree under which it was kept, and this was evidently a rather remote contingency. It would thus appear that it was to all intents and purposes a novice in the art of discriminating caterpillars. The jackdaw having been fed in the morning, at mid-day Miss Gould offered him a larva of the figure-of-eight moth, and she thus reports of his behaviour: "The bird looked at the larva suspiciously for a long time, and would not take it. Then he seized it, and, on tasting it, shook his head violently, evidently disliking it. He then dropped it, but picked it up and tried it again, shook his head as before, and finally put it down on the floor of the cage and refused to eat it." That the hesitation did not arise from any objection to caterpillars *per se*, was shown by the fact that when a smooth green larva was offered, the bird snapped it up at once and ate it with avidity. On another occasion, with the view of testing whether the pangs of hunger would be a sufficient inducement to overcome this reluctance, and thus to determine whether there was a limit to the degree of protection afforded to the caterpillar by its coloration, the jackdaw had been purposely left unfed, so that he was very hungry, and begged for food by carrying his empty food vessel and placing it against the bars of his cage. A large larva of the mullein moth was then given him. "At first he refused it, then took it, but dropped it instantly, shaking his head, and never touched it again. He appeared quite subdued for a time, and sat shaking his head and swallowing. Nor would he take anything else offered him at all for a little while, but finally ate a gooseberry with relish." Two points seem to be substantiated by these experiments; first, that brilliant and conspicuous colouring in a caterpillar is itself deterrent, at least to a jackdaw, and secondly, that this conspicuous coloration is accompanied by a disagreeable taste. Of course, neither of these two means of protection ultimately availed the caterpillar in these particular instances, since it perished from the injuries received by the tasting as surely as if it had been eaten. But though that might be the case in a bird's first experiences of caterpillar diet, a few trials would teach the novice to avoid such caterpillars for the future, and therefore the sacrifice of the life of a few individuals would contribute towards the salvation of the majority, and would thus ultimately tend to the advantage of the

caterpillars as a race. But just as "what is one man's meat is another man's poison," so it seems that there are some birds that are prepared to eat even the caterpillar of the mullein moth, notwithstanding its taste, for Mr. H. D'Orville records that, according to his own observations, some birds in a state of nature do eat this larva, picking it off from its food-plant, the black mullein, on which it feeds exposed and conspicuous.

A very curious instance has been recorded by Weismann. The caterpillar of the cinnabar moth (*Euchelia jacobeæ*) is of a deep orange colour, banded with black, and is apparently distasteful, as might be expected of an insect feeding upon ragwort. At any rate, Weismann found that it was invariably rejected by lizards. Now it so happens that there is another caterpillar which, when young, is also orange banded with black, but which, as befits a creature feeding upon heather, does not appear to be unpalatable. This is the larva of the fox moth (*Lasiocampa rubi*), which, in its more advanced stages, when it is plain reddish-brown, we have already mentioned as having on one occasion, notwithstanding its hairiness, formed the staple food of a particular bee-eater. This caterpillar, in its juvenile clothing of orange and black, Weismann also offered to a lizard. The reptile at first seemed doubtful about it, applying its tongue to it, but not venturing to do more. After retiring for a short time, however, it returned to the attack and swallowed the caterpillar. This was a piece of education to its reptilian mind, apparently teaching it that there might be caterpillars banded with black and yellow which were palatable, as well as distasteful ones. After this experience, therefore, it sometimes went so far as to taste the cinnabar caterpillars, as if to assure itself that they were really disagreeable, and that it was not losing the enjoyment of a tit-bit through prejudice. In such cases, however, it invariably rejected the morsel after tasting, thus plainly showing that while the coloration served as a warning, there was underlying that a real inedibility which justified the avoidance of the caterpillar.

We have already seen that hairy caterpillars are very commonly though not universally rejected by insectivorous vertebrates. Mr. Jenner Weir, experimenting with the same birds as before upon the caterpillars of the tiger moth (*Arctia caja*), the small egger (*Eriogaster lanestris*), the gold tail (*Porthesia auriflua*), and the vapourer (*Orgyia antiqua*), found that they were all rejected, and were not even casually examined, the merest glance seeming to be sufficient to settle the matter. That the objection depended not simply upon the hairs, unless they themselves, as in the case of the gold tail, produced irritation, seems evident from the facts that some hairy larvæ are eaten by birds, and that young and comparatively hairless larvæ of species which become densely hairy when older were tasted by certain birds, but were found disagreeable, and so finally left alone. Hence, there seems to be some justification for the idea that these larvæ are actually disagreeable to the taste, and that the hairs serve as a warning just as do the bright colours mentioned above. It must be confessed, however, that much more evidence is desirable before the exact relations between edibility, brilliant coloration, and hairiness in larvæ, and the influence of these upon insectivorous vertebrates, can be stated with the comprehensiveness of a general law. If any of our readers have opportunities of making such observations, they would materially contribute towards the solution of the problem by preserving minute and accurate records of the facts observed, and of all circumstances that appear to have any bearing, however remote, upon them.

(*To be continued.*)

THE ASTRONOMY OF SHAKSPEARE.

By Lieut.-Col. E. E. MARKWICK, F.R.A.S.

IN the enormous amount of literature which has come forth in connection with Shakspeare, most probably every special science or profession touched on in his writings has been taken up by someone or other, and all the passages bearing on the subject brought together and collated, thus giving an idea how far the great master was acquainted with it.

Without pretending to any special knowledge of what has been written to elucidate the plays of Shakspeare, I thought it would be interesting to note all passages in the dramas touching on astronomy or the heavenly bodies. Before entering upon a discussion of these, it will be well to note the state of popular astronomy in Shakspeare's time.

Taking 1608 as about the date when he was in the full enjoyment of his splendid powers as a dramatist, it will be remembered that Copernicus had then been dead some sixty-five years, but his ideas had gained but few adherents. Tycho Brahe died at the beginning of the seventeenth century, and possibly Shakspeare may have heard of him in connection with that wonderful star which appeared in 1572, and which is sometimes called Tycho's star. Galileo, born in 1564, was in 1610 making discoveries of planetary wonders with the newly-invented telescope. Kepler, born in 1571, was at the period of our poet's zenith commencing his researches into the motions of the planets, which ultimately resulted in the announcement of his celebrated three laws. We know that Kepler particularly directed his attention to the planet Mars, which as it were became the criterion for the other planets. Now in *Henry VI.*, Part I., Act I., Scene II., we find Charles observing—

> "Mars his true moving, even as in the heavens,
> So in the earth, to this day is not known."

Is it possible that Shakspeare, through his mouthpiece, may here be alluding to Kepler's studies in connection with the planet? or has the passage only reference to the then generally incomplete knowledge of the cause of the movements of the planets?

Public or national observatories had not yet been established, unless, perhaps, we except the magnificent building called Uraniburg, in which Tycho was installed on the island of Huenna, in the Baltic. It was here that James the First of England paid a visit of eight days to Tycho, "when he went to Denmark to complete his marriage with a Danish princess." Monarchs of the present day would be few and far between who would be sufficiently smitten with the charms of Urania to sojourn for a week with a professional astronomer; neither would the means of the latter be sumptuous enough to enable him to entertain royalty.

The general knowledge of astronomy in those days was probably confined to an acquaintance with a few of the constellations, and being able to detect the planet or planets of the season. What was known was simply the result of naked eye observation. It was not yet the day of the modern "amateur astronomer." In fact, at the time of which we are speaking, astronomy proper was merely a handmaid to astrology. The former simply gave the necessary data for ascertaining the positions of the heavenly bodies at any time, to enable a nativity or horoscope to be cast. Astrology, at least in the popular eye, was *the* profession, and no doubt a lucrative one to anyone who had made a name at this sort of work. Every person of any importance, rank, or position had his or her horoscope cast, and the belief in the influence of the planets

on men and mundane affairs was deeply rooted in the popular mind. Consequently we find frequent allusions to this celestial influence, and the power of the planets to "strike." Yet in two places the master is bold enough to avow, through his characters, his disbelief in astrology. Cassius in *Julius Cæsar* observes—

> "The fault, dear Brutus, is not in our stars,
> But in ourselves, that we are underlings."

Again, in *King Lear*, we have the following thoroughly Shakspearean bit of dialogue—

GLO.: "These late eclipses in the sun and moon portend no good to us: though the wisdom of nature can reason it thus and thus, yet nature finds itself scourged by the sequent effects," etc.

EDMUND: "This is the excellent foppery of the world! that, when we are sick in fortune (often the surfeit of our own behaviour), we make guilty of our disasters the sun, the moon, and stars: as if we were villains on necessity; fools by heavenly compulsion; knaves, thieves, and treachers by spherical predominance; drunkards, liars, and adulterers, by an enforced obedience of planetary influence; and all that we are evil in, by a divine thrusting on."

The rest of the passage is not quite suitable for quotation, but is nevertheless soundly true.

What strikes one in looking over the passages noted is the frequent reference to the "spheres" in which the sun, moon, planets and stars were supposed to move. The doctrine of *crystalline spheres* seems to have been "first taught by Eudoxus, who lived about three hundred and seventy years before Christ. According to this system, the heavenly bodies are set like gems in hollow orbs, composed of crystal so transparent that no inner orb obstructs in the least the view of any of the orbs that lie behind it. The sun and the planets have each its separate orb, but the fixed stars are all set in the same grand orb; and beyond this is another still, the *primum mobile*, which revolves daily, from east to west, and carries along with it all the other orbs. Above the whole spreads the *grand empyrean*, or third heavens, the abode of perpetual serenity." (Mitchell, "Orbs of Heaven," p. 287, fourth edition.) This idea seems to have been thoroughly ingrained into Shakspeare's mind. Of course it in no way interfered with the systems either of Ptolemy, Tycho Brahe, or Copernicus. A transparent sphere was provided for each planet, and the difficulty was to prove that it did not exist.

In *The Tempest*, Gonzalo says—

"You are gentlemen of brave metal; you would lift the moon out of her sphere, if she would continue in it five weeks without changing."

In *Midsummer Night's Dream*, Fairy says—

> "I do wander everywhere
> Swifter than the moon's sphere."

In *As You Like It* we find—

> "And thou, thrice crowned queen of night, survey
> With thy chaste eye from thy pale sphere above. . . ."

And in *A Winter's Tale*—

"Though you would seek to unsphere the stars with oaths."

In *King John*, Bastard observes—

> "Now, now, you stars, that move in your right spheres,
> Where be your powers?"

Again, the principle of each star being alone in its sphere is enounced in the well-known line—

"Two stars keep not their motion in one sphere."

Then we have "the music of the spheres," and "discord in the spheres"; these and other passages showing that the doctrine was a familiar one at the beginning of the seventeenth century.

The connection of the moon with the tides is clearly indicated, as in *The Tempest* Prospero says—

> "His mother was a witch, and one so strong
> That could control the moon, make flows and ebbs,
> And deal in her command, without her power."

In *Measure for Measure* the moon is styled the "governess of floods."

In *A Winter's Tale* we read—

> "By all their influences, you may as well
> Forbid the sea for to obey the moon."

Also Prince Henry, in *Henry IV.*, observes jocosely—

"For the fortunes of us that are the moon's men doth ebb and flow like the sea; being governed as the sea is, by the moon."

Nothing could be more correct in its way than these references to the power of the moon, although the force of gravity had not then been discovered by the great Newton.

Calendars or almanacs must have been in use at the time. Thus, in *Julius Cæsar*, Brutus asks Lucius his servant—

"Is not to-morrow, boy, the ides of March?"

and on receiving the reply that he knew not, tells him to "look in the calendar," and then observes that "the exhalations, whizzing in the air," gave so much light that he could see to read by them. By "exhalations," meteors would here seem to be meant.

In *Midsummer Night's Dream* occurs a curious passage, where Hermia says—

> "I'll believe as soon
> This whole earth may be bored; and that the moon
> May through the centre creep, and so displease
> Her brother's noontide with the Antipodes."

The poetic image here seems to be that the earth might be bored by a cylindrical passage which would just let the moon through. Full moon, too, is evidently referred to, with the moon on the meridian, so that it will be near midnight, and the sun consequently on the meridian at the Antipodes.

Astronomical expressions occur occasionally in the plays. For example, the Zodiac is employed to denominate the year. Speaking of laws or punishments which have long been in abeyance, Shakspeare says—

> "Which have, like unscoured armour, hung by the wall
> So long, that nineteen Zodiacs have gone round."

Again, we read in *Titus Andronicus*, "Gallops the Zodiac in his glistering coach."

The word "meridian" is brought into the following beautiful passage with very happy effect. Wolsey, in predicting his own downfall, says—

> "I have touch'd the highest point of all my greatness:
> And, from that full meridian of my glory,
> I haste now to my setting. I shall fall
> Like a bright exhalation in the evening,
> And no man see me more."

Most have probably witnessed, on some country walk at night, the flash of a meteor across the sky and its almost instantaneous disappearance. Exactly with such suddenness and completion did Wolsey foresee his own fall. Meteors are frequently referred to—not always under this name, however.

In *King John*, Lewis says he was more amazed

> "Than had I seen the vaulty top of heaven
> Figured quite o'er with burning meteors."

Again, in *Richard II.*—

> "And meteors fright the fixed stars of heaven;
> The pale-faced moon looks bloody on the earth," &c.

In the same play, Salisbury, anticipating the downfall of Richard, says—

> "Ah, Richard! with the eyes of heavy mind
> I see thy glory, like a shooting star,
> Fall to the base earth from the firmament!
> Thy sun sets weeping in the lowly west," &c.

The sentiment here is very similar to that in Wolsey's speech just quoted.

Venus seems to be the only planet mentioned other than in an astrological sense. In *Midsummer Night's Dream* occurs the following—

"Yet you, the murderer, look as bright, as clear
As yonder Venus in her glimmering sphere."

Stars and constellations are pretty frequently brought in, or referred to. The north star is held up as an example of fixedness and constancy. Cæsar says of himself—

"But I am constant as the northern star,
Of whose true-fixed and resting quality
There is no fellow in the firmament;
The skies are painted with unnumbered sparks,
They are all fire, and every one doth shine;
But there's but one in all doth hold his place."

In another play we note the comparison "Strong as the axle-tree on which the heavens ride." A tempest at sea is described in the following graphic words—

"The wind-shaked surge, with high and monstrous mane,
Seems to cast water on the burning bear,
And quench the guards of the ever-fixed pole."

Ursa major is mentioned in the following, and it is evident that country people used to note the stars sometimes, to give them an idea of the hour. A carrier, on the early morning before departing from Rochester on the journey when they were attacked by Falstaff and his bogus highwaymen, says—

"Heigh ho! An't be not four by the day, I'll be hanged: Charles' wain is over the new chimney, and yet our horse not packed. What, ostler!"

Here is another constellation mentioned. The expression seems to be another form of our modern proverb, "Carry coals to Newcastle." In *Troilus and Cressida* Ulysses observes—

"And add more coals to Cancer, when he burns
With entertaining great Hyperion."

The reference is evidently to the sun, when in Cancer.

The "seven stars" are occasionally referred to, by which expression I presume we may include the sun, moon and planets, unless it means the Pleiades. Falstaff says—

"Indeed, you come near me now, Hal: for we, that take purses, go by the moon and seven stars, and not by Phœbus."

The same expression occurs in a comic dialogue between Lear and Fool.

Comets are pretty often mentioned, almost always as objects of dread and foreboding fearful disasters. Probably no celestial object was so much stared at in the old days as a comet—see the well-known picture from the Bayeux tapestry of men gazing upwards in wonder at one of these strange visitors. Petruchio, in *Taming of the Shrew*, says—

"And wherefore gaze this goodly company;
As if they saw some wondrous monument,
Some comet, or unusual prodigy?"

Then we have the well-known introduction to *King Henry VI.*—

"Hung be the heavens with black, yield day to night!
Comets, importing change of times and states,
Brandish your crystal tresses in the sky;
And with them scourge the bad revolting stars
That have consented unto Henry's death!"

In *Pericles* we read "But have been gazed on like a comet." And again in another play, a clown, speaking of the rarity of good women, says—

"One in ten, quoth a'! an' we might have a good woman born but one every blazing star, or at an earthquake, 'twould mend the lottery well."

Blazing star would here probably refer to a comet, as meaning a rare event. We have the expression "blaze star" in modern astronomy to denote one of those temporary stars which from time to time—but at very long intervals—burst out in the heavens and astonish mankind. It is doubtful if the expression bears this meaning in the passage quoted; comet would be more probable.

In another place we find Biron, in a speech the drift of which is to depreciate the advantages of study, observing—

"These earthly godfathers of heaven's lights
That give a name to every fixed star,
Have no more profit of their shining nights
Than those that walk, and wot not what they are."

It is a curious expression in the first line, and might now-a-days be well applied to those who have introduced their names and the names of their contemporaries into the geography of Mars.

Sometimes we find what may be called miraculous or wonderful meteorological signs described, as in *Henry VI.*, Part III., where Richard and Edward see what seem to have been mock suns on either side of the true sun.

"Three glorious suns, each one a perfect sun;
Not separated with the rocking clouds,
But sever'd in a pale clear-shining sky.
See, see! they join, embrace, and seem to kiss,
As if they vowed some league inviolable.
Now are they but one lamp, one light, one sun;
In this the heaven figures some event."

Shortly afterwards Edward observes—

"Whate'er it bodes, henceforward will I bear
Upon my target three fair-shining suns."

In *Romeo and Juliet* we have what has been supposed to be an allusion to the Zodiacal light. Juliet says—

"Yon light is not daylight, I know it, I:
It is some meteor that the sun exhales."

At the same time Romeo seems to be pretty certain that the day is coming on, or perhaps that it may be moonlight, for he says—

"I'll say, yon gray is not the morning's eye,
'Tis but the pale reflex of Cynthia's brow."

The powerful influence supposed to be exerted by the moon on mortal men is expressed by Othello—

"It is the very error of the moon;
She comes more nearer earth than she was wont,
And makes men mad."

Her influence on the vegetable world is also mentioned—

"As true as steel, as plantage to the moon," &c.

The word "astronomer," which is rare, comes in, spoken by Imogen—

"O, learn'd indeed were that astronomer
That knew the stars as I his characters;
He'd lay the future open."

We now come to the astrological passages. A glance over them will show how deeply the idea of the influence of the heavenly bodies on men was ingrained in the popular mind, as it comes out in so many different ways. Even now, many astrological expressions survive and are in daily use; such as "disaster," "in the ascendant," "mercurial," "jovial," &c. But three hundred years ago the "skiey influences," it was generally thought, were invincible and fatal, hanging over men and women in such a way that nothing could change them. Hence, the stars and planets are referred to in two senses, favourable and unfavourable. In the former sense we have "truer stars," "good stars," and "constellation right apt"; while in the latter we have "some ill planet," "planets of mishap," "adverse planets," "malignant and ill-boding stars," "thwarting stars," etc. Two planets are actually mentioned in the astrological sense. In *Much Ado*, Don John observes—

"I wonder that thou, being (as thou say'st thou art) born under Saturn, goest about to apply a moral medicine to a mortifying mischief."

Autolycus in *A Winter's Tale* describes himself as "littered under Mercury," and "a snapper up of unconsidered trifles."

In *All's Well* Helena soliloquizes—

"Our remedies oft in ourselves do lie,
Which we ascribe to Heaven; the fated sky
Gives us free scope; only, doth backward pull
Our slow designs, when we ourselves are dull."

XUM

Comets, of course, were considered as special messengers, foreboding changes and disturbances on the earth at large. But they had nothing to do with ordinary folk—

"When beggars die, there are no comets seen;
The heavens themselves blaze forth the death of princes."

Then we hear elsewhere of a "comet of revenge."

A quaint tradition, that about Christmas time the planets could exert no baneful influence, is embodied in the following passage from *Hamlet*—

"Some say, that ever 'gainst that season comes
Wherein our Saviour's birth is celebrated,
The bird of dawning singeth all night long;
And then, they say, no spirit can walk abroad;
The nights are wholesome; then no planets strike,
No fairy takes, nor witch hath power to charm,
So hallowed and so gracious is the time."

Lastly, we may refer to the "man in the moon." Stephano tells Caliban he is the man in the moon, and Caliban then says—

"I have seen thee in her, and I do adore thee; my mistress showed thee me, and thy dog and thy bush."

And Moonshine, in the interlude of *Midsummer Night's Dream*, says—

"All that I have to say is, to tell you, that the lantern is the moon; I, the man in the moon; this thorn-bush, my thorn-bush; and this dog, my dog."

If Shakspeare's astronomy is largely clouded by astrology, in that very respect does he hold the mirror up to Nature and reflect the prevailing ideas of his time. Yet these scattered allusions are, as it were, mere drops in the ocean of his works, which are not for an age, but for all time.

THE FACE OF THE SKY FOR FEBRUARY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS show little diminution in size and number. Conveniently observable minima of Algol occur on February 3rd, 5h. 55m. P.M.; February 20th, 10h. 48m. P.M.; February 23rd, 7h. 37m. P.M.; February 26th, 4h. 26m. P.M.

Mercury is invisible during the first half of February, being too near the Sun. He is in superior conjunction on the 16th. On the 25th he sets at 6h. 10m. P.M., or 40m. after the Sun, with a southern declination of 7° 9′, and an apparent diameter of $5\frac{1}{4}''$, $\frac{96}{100}$ths of the disc being illuminated. On the 28th he sets at 6h. 32m. P.M., or 56m. after the Sun, with a southern declination of 4° 31′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{91}{100}$ths of the disc being illuminated. During the last four days of the month he describes a direct path through part of Aquarius to the borders of Pisces.

Venus is too near the Sun to be observed after the first part of February. On the 1st she rises at 6h. 39m. A.M., or 1h. 2m. before the Sun, with a southern declination of 21° 51′, and an apparent diameter of $10\frac{3}{4}''$, $\frac{93}{100}$ths of the disc being illuminated. On the 11th she rises at 6h. 40m. A.M., or $\frac{3}{4}$h. before the Sun, with a southern declination of 19° 46′, and an apparent diameter of $10\frac{1}{2}''$, about $\frac{94}{100}$ths of the disc being illuminated. After this she is too near the Sun to be observed. While visible she pursues a rapid direct path through Capricornus.

Mars is an evening star, but is rapidly getting fainter and smaller in size. On the 1st he sets at 11h. 30m. P.M., with a northern declination of 9° 33′, and an apparent diameter of 7·6″. On the 19th he sets at the same time, with a northern declination of 14° 0′, and an apparent diameter of $6\frac{3}{4}''$, about $\frac{90}{100}$ths of the disc being illuminated. On the 28th he sets at the same time, with a northern declination of 16° 0′, and an apparent diameter of $6\frac{1}{4}''$. During the month he describes a direct path from the borders of Pisces through a great part of Aries. He is occulted by the Moon on the afternoon of the 21st, but the phenomenon is not visible in these latitudes.

The minor planet Juno comes into opposition on the 14th, when she is distant from the earth about 141,400,000 miles, and appears as bright as an $8\frac{1}{2}$ magnitude star. She sinks on the 24th at 11h. 14m. P.M., with a northern declination of 5° 54′. During February she describes a retrograde path through part of Sextans on to the confines of Hydra and Leo, but without approaching any naked eye star.

Jupiter is still the most conspicuous object in the evening sky, but as he is rapidly approaching the west he should be looked for as soon after sunset as possible. He sets on the 1st at 11h. 3m. P.M., with a northern declination of 6° 36′, and an apparent equatorial diameter of 37″. On the 20th he sets at 10h. 8m. P.M., with a northern declination of 7° 55′, and an apparent equatorial diameter of $35\frac{1}{4}''$. On the 28th he sets at 9h. 46m. P.M., with a northern declination of 3° 32′, and an apparent equatorial diameter of 34·6″. During the month he describes a direct path in Pisces. At 8 P.M. on the 14th he is 10s. and $5\frac{3}{4}'$ north of the 6th magnitude star Ll 2677. At 8h. 45m. P.M. on the 22nd a 9th magnitude star will be 52″ north of the planet. Jupiter is occulted by the Moon in broad daylight on the 20th. The disappearance takes place at 2h. 16m. P.M., at an angle of 15° from the northern point of the lunar disc, and reappears at 3h. 21m. P.M., at an angle of 263°. The planet will be just on the meridian at the time of re-appearance. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the shadow of the second satellite at 7h. 3m. P.M. On the 3rd an occultation disappearance of the first satellite at 8h. 42m. P.M. On the 4th a transit ingress of the first satellite at 5h. 50m. P.M., of its shadow at 7h. 4m. P.M.; a transit egress of the satellite at 8h. 5m. P.M., and of its shadow at 9h. 17m. P.M. On the 5th an eclipse reappearance of the first satellite at 6h. 35m. 1s. P.M. On the 6th an occultation disappearance of the second satellite at 9h. 35m. P.M. On the 7th a transit egress of the third satellite at 7h. 57m. P.M. On the 8th a transit ingress of the shadow of the second satellite at 7h. 14m. P.M.; a transit egress of the satellite at 7h. 22m. P.M., and of its shadow at 9h. 40m. P.M. On the 11th a transit ingress of the first satellite at 7h. 50m. P.M., and of its shadow at 9h. P.M. On the 12th an eclipse reappearance of the first satellite at 8h. 30m. 33s. P.M. On the 15th a transit ingress of the second satellite at 7h. 34m. P.M. On the 17th an eclipse reappearance of the second satellite at 6h. 22m. 51s. P.M. On the 18th an eclipse reappearance of the third satellite at 6h. 19m. 3s. P.M. On the 19th an occultation disappearance of the first satellite at 7h. 12m. P.M. On the 20th a transit egress of the first satellite at 6h. 35m. P.M., and of its shadow at 7h. 37m. P.M. On the 24th an eclipse reappearance of the second satellite at 9h. 0m. 31s. P.M. On the 25th an occultation reappearance of the third satellite at 6h. 44m. P.M., and its eclipse disappearance at 8h. 39m. 18s. P.M. On the 27th a transit ingress of the first satellite at 6h. 22m. P.M., a transit ingress of its shadow at 7h. 20m. P.M., and a transit egress of the satellite at 8h. 36m. P.M. On the 28th an eclipse reappearance of the first satellite at 6h. 50m. 11s. P.M. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, February 12th, 6h. 34m. A.M. Inferior, February 3rd, 10h. 28m. P.M.; February 20th 6h. 22m. P.M.

Saturn is an evening star, rising on the 1st at 10h. 10m. P.M., with a southern declination of 2° 40′, and an apparent equatorial diameter of 17·4″ (the major axis of the ring system being 41½″ in diameter, and the minor 6½″). On the 28th he rises at 8h. 16m. P.M., with a northern declination of 2° 8′, and an apparent equatorial diameter of 17·9″ (the major axis of the ring system being 43″ in diameter, and the minor 6⅓″). Titan is at his greatest eastern elongation at 2·3h. P.M. on the 6th, and at 0·7h. P.M. on the 22nd. Iapetus is at superior conjunction at 1·5h. A.M. on the 14th. The accompanying map * (based upon Cottam's smaller star charts, with a few minor alterations) shows the path of the planet in the constellation Virgo (and the principal stars and nebulæ near) from February 1st to September 1st, the position of the planet on the first day of each month being marked with a cross. The magnitude of the principal stars are: γ Virginis (binary), 3·1; δ Virginis, 3·5; η Virginis, 4·0; 16 Virginis, 5·5; 13, 143 P. xii., 38, 44, and 46 Virginis, 6·0. All the other stars are below the 6th magnitude. The numbers attached to the nebulæ are from Dreyer's new General Catalogue. On the evening of the 3rd a 9·3 magnitude star will be occulted by the planet, the central occultation taking place at about 8h. 50m. P.M. On the evening of the 23rd the planet will be about ⅔° north of 38 Virginis.

As Uranus does not rise till after 11h. P.M. on the last day of the month, we defer an ephemeris of him till March.

Neptune is still well situated for observation. He rises on the 1st at 11h. 44m. A.M., with a northern declination of 20° 12′, and an apparent diameter of 2·6″. On the 28th he rises at 9h. 58m. A.M., with a northern declination of 20° 13′. He is almost stationary in Taurus, to the W.N.W. of the 5¾ magnitude star, Weisse's Bessel², iv. 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

There are no well-marked showers of shooting stars in February. The zodiacal light should be looked for in the west shortly after sunset on the nights from the 3rd to the 21st, when the Moon will not interfere with observation.

The Moon is full at 2h. 11m. A.M. on the 1st; enters her last quarter at 8h. 12m. P.M. on the 8th; is new at 4h. 17m. P.M. on the 16th; and enters her first quarter at 2h. 14m. P.M. on the 23rd. She is in apogee at 4h. A.M. on the 9th (distance from the earth 251,230 miles), and in perigee at 8h. P.M. on the 21st (distance from the earth 229,710 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of January Problem (by J. N. Babson) :—

Key-move: 1. Q to R8.

If 1. . . . K to K4, 2. Q to KRsq, &c.

If 1. . . . K to B6, 2. Q to QR2, &c.

CORRECT SOLUTIONS received from Alpha, W. T. Hurley, and H. S. Brandreth. The latter gives only the minor variation.

E. Reginald Blakely.—(1) After 1. Kt to Q5, K to K4; 2. Q to Kt3ch, K × P, there is no mate. (2) *The Chess-Monthly*, edited by L. Hoffer: published by Horace Cox, Breams Buildings, Chancery Lane, E.C. Annual subscription, 11s., post free.

* The map is not ready in time for this month's issue.—A. C. R.

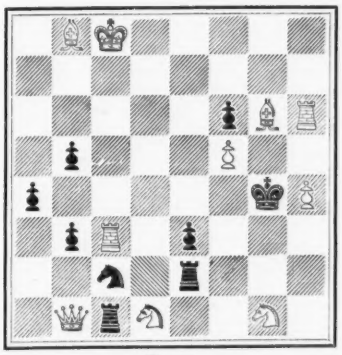
W. T. Hurley.—The idea of another Solution Tourney does not find favour with the proprietors. We hope to make arrangements this month for a Problem Tourney instead, probably for three-movers.

PROBLEM.

By A. F. MACKENZIE, Jamaica.

First Prize in *Pittsburg Dispatch* Tourney.

BLACK.



WHITE.

White to play, and mate in three moves.

[Mr. S. Loyd, one of the judges, describes the above as "a remarkably difficult, original and well-constructed position, commencing with an excellent key, followed by fine strategy." The other judges were even more enthusiastic.]

The following game was played in the telephone match on December 17th.

RUY LOPEZ.

WHITE (Liverpool C. C.).	BLACK (British C. C.).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. Kt to B3
4. P to Q3	4. P to Q3
5. P to B3	5. P to KKt3
6. QKt to Q2	6. B to Kt2
7. Kt to Bsq	7. Castles
8. Kt to K3 (*a*)	8. P to Q4
9. Q to B2 (*b*)	9. P to Q5 (*c*)
10. Kt to B4	10. Kt to Q2
11. Castles	11. Kt to Kt3
12. B × Kt	12. Kt × Kt
13. P × P (*d*)	13. Kt to Kt3
14. B to R4	14. Kt × B
15. Q × Kt	15. P × P
16. B to B4	16. B to Kt5 (*e*)
17. Kt to K5	17. B × Kt (*f*)
18. B × B	18. B to K7
19. KR to Ksq	19. B × P
20. B × QP	20. Q to K2 (*g*)
21. Q to Kt3 !	21. B to R3
22. Q to QB3	22. P to Kt3 (*h*)
23. B to B6	23. Q to B4
24. Q to Q2	24. KR to Ksq (*i*)
25. QR to Bsq	25. Q to Q3
26. Q to Kt5	26. P to B4
27. P to K5	27. Q to Bsq
28. R to K4	28. R to K3 (*j*)
29. R to B3	29. QR to Ksq
30. R to KR3	30. B to Bsq
31. R × P	Resigns.

NOTES.

(*a*) 8. Kt to Kt3 instead would have prevented Black from freeing their game by P to Q4.

(*b*) Probably best. Evidently 9. B × Kt leads to nothing.

(*c*) This move, always so tempting, is not generally good, the Pawns being liable to be broken up ultimately by P to KB4. In the present instance, however, Black gain time by attacking the Knight, and follow up the move very ingeniously.

(*d*) If 13. B × P, B × B; 14. P × Kt, P to Q6, &c. The course adopted gives Black the advantage of two Bishops, White's compensation, if any, lying in the open QB file.

(*e*) 16. . . . P to QB4 would not be good, for Black would break up the Pawns by R to QBsq and P to QKt4.

(*f*) A fatal mistake. 17. . . . B to K3 was the correct reply. 17. . . B to K7 (perhaps their original intention) was not good, *e.g.*, 17. . . . B to K7; 18. KR to Ksq, B × Kt; 19. B × B, B × P; 20. B × QP with the same advantage as in the actual game. In taking the Knight, the London players relied too much on the assumption that Bishops of opposite colours always lead to a draw. Some remarks of ours on "Chess Fallacies," in the June number of KNOWLEDGE, are so appropriate to the present instance that they may be quoted here: "*Fallacy VIII.—That Bishops of opposite colours always tend to a draw.*—The contrary is often the case. Imagine that Black has castled on the King's side, and weakened his position by the move P to KKt3. It is now to White's advantage that each player should lose his King's Bishop, leaving the Bishops of opposite colours. The White Queen's Bishop, in conjunction with the Queen and a Knight or Rook, will then probably be irresistible on the King's side, White's Bishop commanding the holes at KB6 and KR6, while the Black Queen's Bishop is practically useless for defence. The general rule may be stated as follows: If your opponent has all, or nearly all, his Pawns on one colour, get rid, if possible, of his Bishop of the *other colour*. The remaining Bishop may guard some of the Pawns, but he cannot guard what is more important — the *diagonals among the Pawns*." The above remarks exactly describe the present position after the exchange of pieces.

(*g*) This makes matters worse, as now White cleverly gain time by threatening to win the exchange. 20. . . . Q to Ksq and 20. . . . P to Kt4 have been suggested as alternatives, the latter for choice. We should prefer, however, 20. . . . Q to R5, for if White in reply advance one of their Pawns on the King's side their Rooks are thereby prevented from coming into play on that wing.

(*h*) 22. . . . KR to Ksq was probably better. The move must be made soon.

(*i*) 24. . . . Q to KR4 would be met by 25. QR to QBsq and 26. R to B3, &c. 24. . . . Q to Q3 would lose a Pawn on account of 25. Q to Kt5, P to R3, 26. Q to R4.

(*j*) If 28. . . . P to R3, 29. R to KR4, K to R2; 30. R to B3 (threatening mate in 3), B to Bsq; 31. R (B3) to B4 and wins. 28. . . . P to R4 would also lose by 29. P to KKt4! (not 29. R to KR4, K to R2, threatening Q to R3). The Liverpool players conducted the latter half of the game with great skill and ability.

CHESS INTELLIGENCE.

Herr Walbrodt, of Berlin, who was so successful in the late Dresden International Tournament, is now fulfilling an engagement with the Havana Chess Club. Mr. Lasker has also been invited, on the condition that he will play a match with Herr Walbrodt.

After his successes with the Manhattan players, Mr. Lasker's progress received a slight check at the hands of Mr. J. W. Showalter. They played a short match, and after each player had won one game the match was rather tamely abandoned as drawn.

The North *v.* South match at Birmingham, on January 28th, is exciting the greatest interest. The Southern Committee found themselves with no less than 180 names to select their team of 100 from; probably some 60 or 70 of the team will be representatives of London and its suburbs.

The proposed Winter Tournament for amateurs has been postponed till Easter, when it is expected to take place at Cambridge.

Modern Chess Brilliancies is the title of a collection of seventy-five games edited and arranged by Mr. G. H. D. Gossip. Most of the games are briefly annotated, but there is nothing in the notes to alarm the least advanced student. Whether all the games in the selection deserve their place, or not, may perhaps be open to question. Game No. 55 has certainly no pretensions to be classed as one of the two "most brilliant games on record," and postal brilliancies might perhaps have been omitted in favour of such a game as Mason *v.* Winawer, in the last Vienna Tournament. In most respects, however, it is an interesting collection, and quite worth the shilling asked for it. Messrs. Ward and Downey are the publishers.

We have received from Mr. J. E. Whincop, of 23, West Hillary Street, Leeds, a very useful pocket chess-board on the diagram principle. The principle is not new, but has been greatly improved. The board is on solid leather, the chess-men being of ivory or bone. The whole is enclosed in a strong leather case. The price, 3s. 2d. (post free), seems very moderate.

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